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LXII. *Memoir on the Stones said to have fallen from the Heavens. Read in the French National Institute by C. VAUQUELIN* *.

WHILE all Europe resounded with the report of stones fallen from the heavens, and while philosophers, divided in opinion on this subject, were forming hypotheses to explain the origin of them, each according to his own manner, Mr. Edward Howard, an able English chemist, was pursuing in silence the only route which could lead to a solution of the problem. He collected specimens of stones which had fallen at different times, procured as much information as possible respecting them, compared the physical or exterior characters of these bodies; and even did more, in subjecting them to chemical analysis by means as ingenious as exact.

It results from his researches, that the stones which fell in England, in Italy, in Germany, in the East Indies, and in other places, have all such a perfect resemblance that it is almost impossible to distinguish them from each other; and what renders the similitude more perfect and more striking is, that they are composed of the same principles and nearly in the same proportions.

Before the last results of the labour of Mr. Howard were known in France, I had employed myself on the same object; and I have the satisfaction to find in his memoir, which has been since printed, that they perfectly agree with those which I had obtained.

I should have abstained from any public notice of an object which has been treated of in so able a manner by the English chemist, if he himself had not induced me to do so during his residence at Paris; had not the stones which I analysed been from another country; and had not the interest excited by the subject rendered this repetition excusable.

It is therefore to gratify Mr. Howard, to give, if possible, more weight to his experiments, and to enable philosophers to place full confidence in them, rather than to offer any thing new, that I publish this memoir. One of the stones which I examined was transmitted to me by C. Saint-Amans: it fell at Créon, in the parish of Juliac, on the 24th of July 1790, about nine in the evening. This stone appeared in the air under the form of a fire-ball, which was visible in almost the whole of the south of France. A very

* From the *Journal des Mines*, No. 76.

correct account was given of it at that time in the abbé Bertholon's *Journal d'Histoire Naturelle*, together with the proces-verbal of the municipality of the place, which confirmed the fall of this stone.

Another stone was given to me by M. Darcet junior: it fell at Barbotan, near Roquefort, in the month of July 1789. The brother of the late Darcet, curé in the neighbourhood, sent it to him, with the proces-verbal drawn up respecting this extraordinary phænomenon. C. Lomet, who is known to several members of the Institute, was at Agen on the day when this kind of meteor appeared in the atmosphere. The following is the account which he gave me of it:

"It appeared as a very bright fire-ball, the light of which was as pure as that of the sun; it had the size of a common air-balloon, and was long enough visible to throw the inhabitants of the country into the greatest consternation; after which it burst, and disappeared. A few days after, some peasants brought stones, which they said were the result of the fall of the meteor: but at that period they were laughed at. What they said was considered as fables; and those to whom the stones were offered, would not accept of them. The peasants would have now more reason to laugh at philosophers."

The third kind of these stones is that brought from Benares in the East Indies, which fell on the 19th of December 1798, exhibiting the very same phænomena as were observed under similar circumstances in other countries. It was given to me by C. De Drée and by C. Saint-Amans, who brought it from England.

All these stones have a similar appearance, and one might readily believe that they had been detached from the same mass. Their surface is blackish, smooth, and, as it were, varnished by a commencement of fusion. The inside is of a whitish gray colour marked with a greater or less number of brown spots, or spots of a darker gray colour than the rest of the mass. Those, however, found at Benares, and in Yorkshire, are whiter in the interior part than those found in France. There are observed in them white pyrites, the fracture of which is very much lamellated; globules of metallic and ductile iron, some of which weigh 46 English grains; but this iron has a whiter colour, and a greater degree of hardness, than common iron. The cause of this difference will be seen hereafter.

I wished to have been able to subject to a separate analysis each of the constituent principles of these stones sensible to the eye: but they are so intimately mixed, that it was impossible to separate them exactly. By patience, however,

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I was able to obtain a sufficient quantity of the globules of iron and of pyrites to ascertain the nature of them.

A. A hundred parts of the stones of Benares, pulverized in a mortar of hard stone, and sifted through a fine silk sieve to separate the coarsest particles of the iron which cannot be pulverized, were treated with dilute nitric acid. During this operation there was disengaged a large quantity of nitrous gas; the acid assumed a yellowish green colour; the stony powder became whitish, and, dividing itself, increased considerably in volume, so that it resembled gelatinous filix. Sulphureous particles were observed floating at the surface of the liquor.

B. When the action of the nitric acid ceased, water was added to the mixture; the liquor being filtered, the undissolved matter was washed, and after deliccation in the open air it weighed no more than 64 parts.

C. As the matter treated in this manner was still slightly coloured, it was boiled with muriatic acid, which, as is well known, unites more easily with oxidated iron: it assumed also a greenish yellow colour, and the powder became much whiter. After this second operation the stone, when washed and calcined in a platina crucible, weighed only 47 parts.

D. The nitric and muriatic acids which had been successively poured over the stone as above mentioned were mixed together and then precipitated by ammonia, of which an excess was added. Being heated for some time, the liquor was filtered, and the precipitate was washed and calcined: it had a brown colour, and weighed 38 parts.

E. The ammoniacal liquor had a slight blue colour inclining to violet. Alkaline carbonates produced in it no precipitate; on the other hand, caustic alkalies formed a white precipitate very abundant, but the liquor lost none of its violet colour. This precipitate, when washed and dried in the air, had a greenish shade, and weighed 18 parts; calcination reduced it to 13. This matter readily combined with sulphuric acid, and the result was a solution, which by spontaneous evaporation produced prismatic crystals resembling in taste and flavour those of the sulphate of magnesia. It however had a slight greenish colour, and at the end of some minutes produced in the mouth a metallic flavour. To know whether the colour and flavour of the sulphate of magnesia arose from some metallic substances it was dissolved in water, and hydrofulphuret of ammonia being poured over it, a pretty voluminous black precipitate was produced. After washing and deliccation, however, it weighed only two parts. We shall return hereafter to this matter.

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F. The ammoniacal liquor, from which the magnesia had been separated by means of caustic potash, was mixed with a solution of sulphurated hydrogen. By this mixture there was formed a very voluminous black precipitate, which when washed and dried weighed seven parts. This part being united with the three parts obtained also by sulphate of magnesia, and kept at a red heat for some minutes, exhaled the odour of sulphureous acid, and acquired a very dark green colour inclining to brown: the whole then weighed scarcely three parts.

A small quantity of this matter fused with borax gave glass of a hyacinth colour; put into sulphuric acid diluted with water, it dissolved only in part, and a small quantity which had a metallic appearance refused to combine with it; but the addition of a few drops of nitric acid, by oxidating it, favoured its solution: by spontaneous evaporation it furnished elongated crystals of a very beautiful green colour.

By the properties which this matter exhibited it is evident that it was nothing else but oxide of nickel; for it is the only one among the metals which possesses the property of colouring borax of a hyacinth red colour by fusion, of giving to ammonia a purplish blue colour, of forming with sulphuric acid a prismatic salt of a green colour, and of producing by its combination with acids and ammonia triple salts which are not precipitated by fixed alkalies.

An examination of the principles successively obtained by the different means employed for analysing the stone of Benares, proves that it is composed of siliceous magnesia, and iron, a part of which appears to be oxidated, nickel and sulphur. Iron, nickel, and sulphur, according to every appearance, form a particular triple combination, which seems only to be interposed between the earthy parts. I am, however, inclined to believe, that one part at least of these substances is really in combination with the earths; for at the moment when the stone is attacked by the acids, the siliceous shows itself in a state of very great division, and like a kind of jelly. The proportions in which these matters are found in the stone of Benares are nearly as follows:

Siliceous	-	-	-	48
Oxidated iron	-	-	-	38
Magnesia	-	-	-	13
Nickel	-	-	-	3
Sulphur an indeterminate quantity				

If we might suppose that the iron contained in this stone exists in the perfect metallic state, we might easily find, by the increase of weight which it acquires in consequence of oxygenation, the proportion of sulphur; but as it is certain that this metal is oxidated in it in an unknown quantity, that of the sulphur cannot be determined.

A hundred parts of this stone, freed as far as could possibly be done from ferruginous matters, were treated with muriatic acid diluted with a little water. The mixture produced immediately, with a strong effervescence, a gas which had the odour of sulphurated hydrogen gas. The matter assumed the form of a gelatinous mass, which seems to prove, as already said, that the flux exists in this stone in a state of combination either with iron or with other substances.

When the effervescence had subsided, and the mixture had boiled for some time, it was diluted with water and filtered. The liquor had a green colour analogous to that of muriate of iron, but a little darker. The residuum when washed was white, and weighed 49 parts.

The muriatic solution and washings being united together were precipitated by ammonia added in excess, and were stirred for some time with the precipitate.

It has been remarked, that oxidated iron, precipitated in this manner by ammonia, has a more intense colour than that of iron obtained under the same circumstances. This iron, washed and dried, weighed 42 parts.

The liquor containing the superabundant ammonia in the precipitation of the iron had acquired a violet colour, which neither the heat nor the contact of the air made it lose. Alkaline carbonates produced in it no alteration; on the other hand, fixed caustic alkalies formed in it a white precipitate pretty abundant, which when washed and calcined weighed twelve parts. This matter combined with sulphuric acid gave sulphate of magnesia, coloured green by a small quantity of nickel which the magnesia had carried down with it.

The liquor from which this earth had been separated by potash had lost a part of its violet colour; it, however, still formed a black precipitate with sulphurated hydrogen. From what I had before observed, I entertained no doubt that the substance which coloured the magnesia green, and was precipitated black by hydro-sulphuret of ammonia, was nickel. I therefore separated, by means of this reagent, the portion which remained in solution and that which was mixed with the sulphate of magnesia: I united them, and having calcined them to separate the sulphur, I obtained a green oxide, which weighed three parts and a half.

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The method employed to separate the iron and the magnesia is founded on this circumstance, that a solution of that earth containing an excess of acid is not precipitated by ammonia, because there is formed a triple salt, which cannot be decomposed by a superabundance of that alkali; but the acid must be in such quantity that the salt resulting from its combination with the ammonia may be able to saturate the salt of magnesia existing in the liquor. Care was taken to observe this.

Alkaline carbonates produce no precipitation of the substances which enter into combination with the triple salt here mentioned, though it must, however, be decomposed; but there is formed another kind, composed of magnesia, carbonic acid, and ammonia, which remains in solution. But one thing I did not foresee was the simultaneous precipitation of a portion of nickel and magnesia by the caustic potash; for, as Mr. Howard remarked, this metal is found there in complex combination, the oxide of which ought to be dissolved by the ammonia in proportion as it becomes free: the precipitation of this metal must be produced by its affinity for magnesia, at least this is what appears most probable.

After these two analyses of the stone of Benares, and the conformity of the results which they furnished, though effected by methods somewhat different, there can be no doubt that it is really composed of iron, silex, magnesia, nickel, and sulphur, as Mr. Howard announced.

Having therefore confirmed by these two means, and by others, which it is needless to mention, the results given by the English chemist in regard to the composition of the stone of Benares, I subjected to similar experiments two other kinds of stone which fell in France, in order to ascertain whether they would furnish the same principles of analysis as their external characters seemed to announce.

To avoid a repetition of the details already given of the analytical methods employed, I shall only observe, that the stones which fell at Barbotan and Juliac, treated with sulphuric, nitric, muriatic, &c. acids, exhibited in the series of operations to which they were subjected, and by the nature of the elements which they furnished, the most perfect similarity to the preceding. It may therefore be considered as fully proved, that the stones said to have fallen from the clouds in different countries are composed of principles perfectly similar, and consequently that we must have recourse to a common cause to explain their formation, and to suppose also a common source from which nature derived the elements of them. I must, however, acknowledge, that the
specimens

specimens of the stones which have fallen in France are a little more charged with iron than those of other countries ; but as this metal exists in them, for the most part, in distinct globules which cannot be pulverized, they could have no influence on the results of the analysis, as the earthy part was sifted through a fine sieve.

All the stones which have fallen to the earth, and particularly in France, contain, as I have already mentioned several times, globules of iron in a metallic state more or less distinct, some of which weigh from forty to sixty English grains. It appeared to me of importance to subject this iron to some analytical trials in order to ascertain the nature of their constituent principles ; but before I give the results it may be of utility that I should first give an account of their physical characters. These globules are much whiter than common iron ; their colour approaches that of tin ; their hardness is also greater, and consequently they are more difficult to be forged.

This metal dissolves easily, and with effervescence, in all those acids which dissolve common iron ; but instead of giving pure hydrogen gas, it furnishes hydrogen gas very sensibly sulphurated. A part only of this hydrogen gas, indeed, is combined with the sulphur ; for, having made it to pass through water and caustic alkalies, the greater part of this fluid was not dissolved ; and after having made the different liquids here mentioned to pass in the same manner, no sensible signs of sulphur were given by reagents ; but the water and the alkalies were manifestly hydro-sulphurated, since they then precipitated black the greater part of metallic solutions, and particularly lead. This sulphurated hydrogen gas exhibited to me a phenomenon which, as far as I know, has never been before observed in its combination with water—I mean a very speedy decomposition which it experienced in a flask perfectly closed in which it had been preserved for some days. At the end of that time there were at the bottom of the water a great many small white laminæ, and the water had no odour : it no longer precipitated solutions of lead. This gas then had experienced complete decomposition.

The solution of this iron in muriatic acid was precipitated by ammonia, of which a superabundance was added. The liquor when filtered had a colour inclining to purple ; the oxide of iron, when washed and calcined, was of a brown colour, and had sensibly increased in weight. The ammoniacal liquor when subjected to evaporation deposited slight traces of iron, but as long as there was ammonia in excess
it

it retained its blue colour, which, as soon as this free alkali was evaporated, was changed to a meadow green. The liquor constantly preserved this colour, which still acquired greater intensity until complete evaporation, and without forming any deposit, which proves that nickel existed in the combination in the state of a triple salt.

Fixed caustic alkalies occasion no precipitation in this liquor; but they make it resume its blue colour by decomposing the muriate of ammonia and laying bare its base, which then redissolves the nickel.

The hydro-sulphurets formed in it an abundant black deposit; and this was the method employed for obtaining the nickel separate. The hydro-sulphuret of this metal, calcined in a platina crucible, left a powder of a dark meadow-green colour, which had all the properties of oxide of nickel.

The iron contained in the stones which have fallen from the heavens is therefore combined with sulphur and nickel; whence it appears very probable that these two substances, which always present themselves in a quantity more or less considerable in the analysis of the whole stones, arise from a similar combination, which it is impossible, whatever care may be taken, to separate exactly from the earthy parts.

The presence of nickel and of sulphur in this iron explains why it is whiter, harder, and less ductile than common iron.

Though I did not ascertain very exactly the quantities of these substances in the iron, I think I may assert that they do not amount to more than five or six per cent. In regard to the pyrites diffused here and there throughout these stones, it is formed, as Mr. Howard says, of iron, sulphur, and a small quantity of nickel; but I was not able to ascertain in what proportions these three substances are united, because I had not a sufficient quantity to subject them to an exact analysis.

It appears to result from all the information obtained, and from testimonies worthy of credit, 1st, That masses, sometimes of considerable size, have fallen to the surface of the earth: 2d, That these masses penetrated with fire move in the atmosphere like inflamed balls, which throw light and heat, and to a great distance: 3d, That they seem to have received a motion parallel to the horizon, though they really describe a curve: 4th, That they fall in a state of softness or fusion like paste, as is attested by their varnished surface, and the impressions formed on them by the bodies which they meet with: 5th, That some of them have fallen in England, Germany, Italy, France, and the East Indies: 6th, That all

these stones have a resemblance to each other by their physical characters and their chemical composition.

What are the causes which can produce stones of this kind, and communicate to them so rapid and so singular a motion? How comes it they are always penetrated with fire? These are questions for which at present it would be difficult to assign plausible reasons.

But whatever these causes may be, if multiple they must be of the same nature, since all the stones which have fallen in countries so different have in every respect a resemblance to each other.

Do they owe their origin to volcanoes? But where are these volcanoes? We are not yet acquainted with them; and stones similar to those in question have never been found among the productions of any of the known volcanoes. Is the atmosphere the medium in which they are formed? But how can we conceive that substances so heavy as earths and metals could exist in sufficient quantity, and remain long enough suspended in a fluid so light as air? If we suppose that these bodies existed in the atmosphere, whence did they originally come, and what means were so powerful as to unite them, and to form of them masses so heavy and so voluminous?

The opinion which makes them come from the moon, however extraordinary it may appear, is, perhaps, the least improbable; and if it be true, that no direct proofs can be given of this opinion, it is equally certain that no well-founded reasoning can be opposed to it.

The most prudent course to be pursued in this state of things is freely to acknowledge, that we are entirely unacquainted with the origin of these stones, and of the causes which produced them.

LXIII. *Conjectures on the Stones which have fallen from the Atmosphere.* By EUSEBIUS SALVERTE*.

THE ancients never entertained any doubt in regard to what they observed. As the natural sciences among them were only collections of facts, no theory compelled them to contradict their observations. We accuse them of often having seen without examining; but though we examine better ourselves, we are often obliged to abjure our scepticism, and at length to see what the ancients saw before us.

* From the *Annales de Chimie*, No. 133.