XIV. *Observations on a new Species of hard Carbonate of Lime; also on a new Species of Oxide of Iron. By the Count de* Bournon, *F. R. S. and L. S.*

Read May 26, 1803.

CARBONATE OF LIME.

A PARTICULAR investigation which I undertook to make, of the immense variety of forms presented to us by the carbonate of lime, (many of which have never yet been described,) having led me to observe more accurately some specimens I had before examined, my attention was forcibly attracted by a group of hexaedral pyramidal crystals, which are in Mr. GREVILLE's noble collection. As the exterior appearance of these crystals was different from that which is peculiar to carbonate of lime, I was desirous to ascertain their nature, and therefore endeavoured to bring them, by splitting, into the primitive rhomboidal form of this substance; but, upon making the attempt, I perceived, to my great astonishment, not only that I was not able to obtain any fracture that could possibly belong to the planes of the primitive rhomboid, but also, that the substance strongly resisted every attempt I made to procure a fracture in any other direction. In fact, every fracture I could obtain was irregular, and possessed more or less of that vitreous appearance which is peculiar to the greater number of hard stones. So remarkable was the hardness of this substance, that, although the points of the crystals were very thin, and consequently might be supposed very brittle, yet they resisted my efforts to break them, in a very remarkable manner.

The resistance above spoken of appearing to me analogous to that of hard stones, I resolved to examine, with the most scrupulous attention, every thing relating to the peculiar characters of this substance.

Its hardness is very superior to that of common carbonate of lime, being such as to scratch very easily the fluate of lime; and, when rubbed with force upon glass, it takes off the polish of its surface, and sometimes leaves scratches upon it.

Its specific gravity, I found to be 2912.

This substance, of which I have since had an opportunity of observing a great number of specimens, I have always found to be without colour; and its crystals are very often perfectly transparent.

When powdered, and thrown upon a piece of iron heated nearly to redness, in a place that is perfectly dark, it occasions a very weak phosphorescent white light; this light is only sufficient to mark the place where the powder is thrown.

Its lustre is much greater than that of common carbonate of lime.

When put into nitric acid, a violent effervescence is produced; and it is very quickly dissolved, without leaving the smallest residuum.

Although this substance strongly resists any effort made to divide it by splitting, yet it shows a tendency to admit of being divided more easily in two directions, which would produce a rhomboidal tetraedral prism. I succeeded indeed, at last, though with great difficulty, and after many fruitless attempts, in procuring from it a perfect rhomboidal tetraedral prism, the angles of which measured 128° and 52. (See Plate VI. Fig. 1.) I found it, however, impossible to obtain any smooth and even fractures on the terminal faces of this prism.

In some crystals, which were situated at the base of those which constituted the largest of the groups I examined, I observed perfectly-formed hexaedral prisms, which appeared to me to have been occasioned by the two angles of 52° (belonging to the rhomboidal tetraedral prism of 128° and 52°, which I have just described,) having been replaced; consequently, there were now two edges of 128°, and four others of 116°. See Fig. 2.

The principal crystals which form the above group, although they are about three inches in length, do not show themselves distinctly, except at their upper extremity, being joined together, and entangled with each other, throughout the rest of their length. The upper extremity just mentioned, is a very sharp hexaedral pyramid, as in Fig. 3. The solid angle of its summit, taken upon two of the opposite sides, is of 15°; and the sides of the pyramids, meeting together, form two angles of 128° each, and four others of 116°, as we have already seen to be the case with respect to the sides of the hexaedral prism; consequently, the base of this pyramid is an irregular hexagon.

Although the summit of this pyramid is sometimes formed in the manner above described, by the meeting of all its planes at the same point, (as is seen in Fig. 3,) yet it more frequently happens that the summit terminates in a ridge; the pyramid is then of a cuneiform shape, on account of the extension (which is sometimes very considerable) of two of its opposite sides, at the expense of the others, as in Fig. 4. Very frequently, indeed, the abovementioned extension is such as to cause the pyramids to be extremely thin; they then appear in the form of a very acute isosceles triangle, the summit of which is truncated, and the sides of which are slightly bevelled. The bevel, however, is often so inconsiderable as to be scarcely perceptible. See Fig. 5.

Each of the two sides which, in those pyramids, acquire the abovementioned extension of surface, at the expense of the two others, has constantly appeared to me to belong to one of the sides which forms the angle of 128°, but taken in an opposite direction, as is represented in Fig. 6, which is supposed to be the base of one of them. This base is perfectly similar, in the measure of its angles, to that of the hexaedral prism of Fig. 2; nevertheless, this hexaedral prism sometimes appears also to have the two planes, which have replaced the edges of 52°, more extended than the four others.

In those crystals which are the most detached from each other, and exhibit a larger portion of their extent, it may be distinctly perceived, that the above pyramid is situated upon a hexaedral prism, of the same dimensions as the base of the pyramid; (see Fig. 7;) but, as the angle formed by the junction of the sides of the prism with those of the pyramid is extremely obtuse, (its measure being 172° 30',) the exact point of union of the prism with the pyramid cannot easily be distinguished.

The summit of the pyramid is sometimes replaced by two trapezoidal planes, situated, when the pyramid is of a cuneiform shape, on the broadest sides. These planes meet together, at the summit, in a ridge of 110°, and form, with the sides of the pyramid, on which they incline, an angle of 132° 30'. See Fig. 8.

At other times, this summit is replaced by two planes situated differently from the above, being placed on one of the edges contiguous to each of the two broad sides of the pyramid, and in opposition to each other. These planes, which are irregular pentagons, meet together at the summit, in a ridge which is perpendicular to the axis, and form, with the edges of the pyramids, on which they incline, an angle of 140°, as in Fig. 9. These planes are sometimes very distinctly striated, the striæ being directed towards the summit; but, by following these striæ over the whole surface of the crystal, it evidently appears, that they are occasioned by the aggregation of a greater or smaller number of very thin crystals, which are united by the broadest sides of their pyramids.

Many of the crystals exhibit this variety combined with that represented in Fig. 8, as is seen in Fig. 10. The summit of the crystal is then terminated by a small tetraedral pyramid.

It frequently happens, that there exists only one of the planes of the diedral summit, represented in Fig. 9. It nevertheless intercepts the summit of the pyramid, which then becomes terminated by a hexagonal plane, inclined upon one of the edges contiguous to one of the broad sides, in such a way as to form with it an angle of 140°. (See Fig. 11.) These crystals are very often so considerably flattened, as to have nearly the appearance of very sharp isosceles triangular laminæ, which have their summits truncated, in such a manner as to form with one of the broad sides an angle of 140°, as in Fig. 12. I have seen crystals of this variety, the thickness of which scarcely exceeded that of a sheet of paper; yet, notwithstanding their thinness, I found that they might easily be handled, without danger of being broken.

Lastly, the summit of the hexaedral pyramid is sometimes terminated by a plane that is perpendicular to its axis. But I have never seen this last variety, except in combination with that represented in Fig. 9. This combination is shown in Fig. 13.

The above are all the forms I have been able to discover, in the species of carbonate of lime here described.

This substance does not appear to be very scarce. Among the crystallized carbonates of lime preserved in Mr. GREVILLE'S collection, I have met with about a dozen specimens of it, most of which came either from Carinthia, or from Transylvania, or from Scotland. The beautiful and delicately white stalactitical substance, hitherto known by the name of *flos ferri*, generally belongs to the substance here described, particularly certain pieces of it, which have their ramifications covered with small brilliant asperities, giving them the appearance of fine satin. These little asperities, all of which are inclined, in the same direction, to the axes of the various ramifications, are in fact so many very perfect but minute crystals, which most commonly belong to the forementioned flat pyramidal varieties.

Among the specimens of this kind of carbonate of lime which came from Carinthia, there exist some, in which the sharp pyramids are very small, and appear as if planted almost perpendicularly in the matrix. These specimens may, from the above circumstance, be more easily confounded with the common carbonate of lime in small needle-like crystals; there is, however, the following difference between them, namely, that in the common carbonate of lime, we cannot touch these little crystals, though ever so lightly, without breaking them; whereas, in the substance here described, the crystals are capable of resisting a tolerably strong compression of the fingers, and, if the pressure be increased, they very frequently, instead of breaking off, actually penetrate into the skin. The lustre of the latter substance is also much more lively than that of the former.

Another circumstance which might prevent our recognizing, at the first view, the crystals of this substance, when placed among those of common carbonates of lime, is, that the crystals of the latter substance are sometimes found in the form of a hexaedral pyramid, nearly as acute as that of the crystals above described; but, in that case, they break with the greatest facility, and the fractures are always smooth, and in the direction of the planes of the primitive rhomboid; a circumstance that is never observed in the crystals of the hard carbonate.

The matrix of this substance, in most of the specimens I have seen, is a brown oxide of iron, mixed with a portion of argill, and also with a considerable number of calcareous particles. In some of these may be observed the primitive rhomboid of the common carbonate of lime, grouped upon the crystals of the substance here treated of.

It may perhaps be questioned, whether the hard carbonate of lime I am now describing, (the mineralogical characters of which seem so much at variance with the chemical ones,) ought not to be referred to that kind which mineralogists have been already obliged to separate from the others, under the name of Arragonite, or whether it ought to be considered as different from the latter substance, and forming an additional new species, among the combinations of the carbonic acid with lime. It appears to me very difficult to determine the above question. The primitive crystal which I obtained from it, is not sufficiently perfect to serve as an accurate criterion; for, as we have seen, that crystal, which is a rhomboidal tetraedral prism, cannot be divided according to its basis, that is, in one of its three natural directions; and this is exactly similar to what happens with respect to the primitive crystal obtained from the Arragonite. I confess, however, that if I were obliged to adopt an opinion, I should be inclined to consider these two substances as distinct from each other.

I shall now take a short view of the analogy, and of the difference, existing in the characters of the two substances just mentioned.

Their specific gravity is nearly the same. The Abbé HAUY states that of the Arragonite at 2946. I found that of the hard carbonate of lime to be 2912.

The hardness of the latter is rather greater than that of the former: it scratches the Arragonite, but is not scratched by it.

The Arragonite is seldom found without a tinge, more or less considerable, of purple; but I have never observed any appearance of colour in the hard carbonate of lime.

The Arragonite, when thrown upon a heated iron, emits a very brilliant phosphorescent light, of a yellowish-orange colour. The other substance, when treated in the same manner, produces only a white phosphorescent light, scarcely perceptible.

From the Arragonite is obtained, by splitting, a rhomboidal tetraedral prism, of 116° and 64°; and, from the hard carbonate of lime, one of 128° and 52°.

The last-mentioned substance, in its secondary forms, passes into a hexaedral prism, which has two edges of 128°, and four others of 116°. Whereas, the Arragonite becomes a hexaedral prism only in consequence of the union of several of its rhomboidal prisms; and as, in that state, three of the edges of the prism are formed by the union of the edges of 64°, belonging to the tetraedral prism, it has three angles of 116°, and three others of 128°. This gives 732°, for the whole measure of the angles of the prism; which measure is too great by 12°; and is the cause that, in the formation of the prism, the rhomboids of which it is composed, are obliged sometimes to penetrate each other; at other times, to form a re-entering angle, at the angles of 128°.

In another secondary form assumed by the Arragonite, there is a diedral summit with isosceles triangular planes, which are inclined upon the edges of 64°, belonging to the tetraedral prism, and meet together in a ridge of 110°. I have not perceived any trace of this form, in the kind of carbonate of lime treated of in this Paper; nor have I perceived the smallest trace of the pyramidal forms of the last-mentioned substance, among the crystals of the Arragonite.

Neither the hard carbonate of lime nor the Arragonite exhibit, by their chemical analysis, any signs of the cause that occasions them to differ from the common carbonate of lime. The Arragonite has been very carefully analysed by MM. KLAPROTH, VAUQUELIN, and THENARD; but their analyses did not show that it differed, in the smallest degree, from the common carbonate of lime. I desired Mr. CHENEVIX to be so good as to analyse the hard carbonate of lime; but his result was not more satisfactory. The cause of its difference from common carbonate of lime remains still undiscovered; yet there certainly exists a considerable difference between the two substances, and one which even the chemist is compelled to admit, when he takes the hard carbonate of lime into his hands, and which becomes still more evident to him, the moment he begins to reduce it into powder. It is however very clear, that the said difference arises from a cause which has hitherto eluded the investigations of chemistry. It may perhaps be supposed, that it is owing to the constituent particles of the substance being more closely connected; and this indeed might be sufficient to occasion a greater degree of specific gravity, and of hardness. But, in the first place, it may be asked what can produce this more intimate connection, of which we find no other example in the immense quantity of crystallized carbonate of lime that has been hitherto examined, however perfect the form of the crystals, or however great their degree of transparency. In the second place, why should the above-mentioned cause change the character of the crystalline forms of carbonate of lime, when we see no instance of such a change in the crystalline forms of other substances, even when they show, by an increase in their hardness, in their specific gravity, and in their transparency, that a closer connection between their constituent particles has actually taken place.

It appears therefore impossible, in the present state of our knowledge, to determine the cause of the very great difference that exists between the common carbonate of lime and the hard kind here treated of; yet it is equally impossible not to be sensible, that the said difference is of such a nature as absolutely prevents us from considering them as of the same species. Whether it is right to join the hard carbonate of lime with the Arragonite, is a question I have already in some measure discussed, but respecting which, until I have had further opportunities of investigating the matter, I shall not venture to give a decided opinion.*

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* I have lately received, from my worthy friend M. GILLET DE L'AUMONT, some imperfectly formed and colourless crystals of hard carbonate of lime, which, he says, were found inclosed in lava, near Vertzou, in the environs of Puy de Dome, in Auvergne, and which were considered as a kind of Arragonite. These crystals appear to me very similar to the hard carbonate of lime herein described; and M. GILLET informs me, that the above is not the only part of Auvergne in which these crystals are found in old lava. I remember perfectly well, that when I was examining the volcanic products of that province, on the spot, and also those of Velay, of Vivarais, and of Forez, I observed, in many of the lavas of the extinct volcanos of those provinces, groups of thin diverging crystals of carbonate of lime, which appeared to me much harder than crystals of common carbonate of lime in similar circumstances, so that I found it very easy to preserve them entire. I think it very probable, that the *Arragonite cylindroide* of the Abbé HAUY ought to be referred to this substance.

CUBIC OXIDE OF IRON.

Amongst the various examples which mineralogy, when studied with attention, constantly offers to us, of several different species being included in the combination of the same modifying substance with the same base, iron may be considered as affording one of the most striking. This metal, in its combinations with oxygen, varies considerably; insomuch that it presents us with several different species, according as the proportion of oxygen in the combination is increased. Thus, by the first degree of oxidation in which this metal offers itself to our notice, is formed the very attractable oxide of iron, which crystallizes in regular octaedrons. By the second degree of oxidation, in which there is a greater proportion of oxygen, a different oxide is produced, which is much less attractable than the former, and crystallizes in the form of a slightly acute rhomboid. Lastly, in the third degree of oxidation, in consequence of a still greater proportion of oxygen, the attractable property no longer exists; the power of crystallizing entirely ceases; and we have the ores called hæmatites, and the other earthy oxides, for instance, the brown, the red, the yellow, and the black, (the appearance of which latter very much resembles that of a bitumen,) between which there certainly exists some real chemical difference, that will probably hereafter be discovered.

The distinction of species here spoken of will perhaps appear extraordinary, to those persons who are accustomed to consider the combination of oxygen with iron as forming of itself a species in the genus, (which genus is determined by the nature of the metal, namely, iron,) because it may appear to them like dividing into various species, that which merely constitutes a single one. But I must observe, that in mineralogy it is not merely the chemical combination of a particular acid with a particular basis which forms the species, but the mode in which that acid is combined with the basis. Perhaps, in many cases, the formation of the species may depend upon the introduction of a third principle, which, either from its mode of combination or from its nature, has hitherto eluded the investigations of chemistry. Thus, in the analysis of two plants, or of two animals, of totally different species, chemistry, in most cases, is not able to discover any thing but the same ingredients combined with each other. In these instances, therefore, it is evident that the mode of combination, and not the combination itself, is what determines the species.

The science of mineralogy is indebted to the Abbé HAUY, for having ascertained the primitive form of the slightly attractable oxide of iron, formerly known by the name of specular iron ore, to which he has given the name of *fer oligiste.* That form was supposed to be derived from the cube; but the Abbé HAUY, directed thereto by the secondary crystals, has shown that it belongs to a rhomboid of 87° and 93°. Nevertheless, the cube must not be excluded from among the forms belonging to the oxides of iron. On the contrary, it constitutes a particular species, which has hitherto been entirely overlooked by mineralogists.

Between the slightly attractable oxide of iron, (or specular iron ore,) and that kind which no longer crystallizes, except in a very indeterminate form, nature has placed another species, the surface of which is of a gray colour, and has a specular appearance, pretty much like the iron ore from the island of Elba. This kind is not at all acted upon by the magnet; and seems to be in the last degree of oxidation in which iron retains the property of crystallizing in a regular form.

Its form is a perfect cube, the edges or solid angles of which are sometimes replaced by small planes.

Its fracture is conchoidal: it has a smooth grain, with a small degree of lustre; and, although it is impossible to make a regular fracture in any particular direction, yet the fracture shows that the crystalline laminæ, or collection of molecules, are situated on the surface of the cube.

Its hardness is rather inferior to that of the slightly attractable oxide of iron.

Its specific gravity is very low; I found it to be only 3961.

Its powder is more red than that of the slightly attractable oxide of iron, but has not the yellow cast observed in the powder of the hæmatite.

To this species ought to be referred the *eisen-glimmer* of the Germans, when it is not attractable: when, on the contrary, it is attractable, it belongs to the slightly attractable oxide of iron. In the first case, this *eisen-glimmer* is in small laminæ, which are very brilliant, but of an indeterminate form; and it frequently is found accompanying the hæmatites, and having the abovementioned appearance. If, in the formation of the hæmatites, some particles of the oxide of iron of which they are composed happen to contain a rather smaller proportion of oxygen, they naturally become the cubic oxide of iron here treated of. Indeed, some hæmatites, although they are crystallized in a very indeterminate manner, and are really of a species different from the cubic oxide of iron, show, by the colour and brilliancy of their surface, a tendency to approach towards it.

When the octaedral very attractable oxide of iron (the *fer oxidulé* of the Abbé Hauy) is in irregular and confused masses, the cubic oxide of iron here described is sometimes found mixed with it; and, in that case, it renders the ore less sensible to the influence of the magnet, in proportion to the quantity of it contained in the mixture. Its presence may be easily detected, when the ore is pounded, by the appearance of a red powder, which shows itself in the middle of the black powder of the aforesaid ore.

Among the specimens of iron ore from Gellivare, in Swedish Lapland, which were brought here by Mr. SWEDENSTIERNA, a very intelligent Swedish mineralogist, there were some, in which this cubic oxide of iron was so pure and unmixed, that they were not at all, or at least in a very slight degree, acted upon by the magnet; but, that they really belonged to the species here treated of, might be plainly perceived, by pretty strongly marked striæ upon the surface, which crossed each other at right angles, and were sometimes even seen within the substance. In other specimens, the cubic oxide of iron was mixed, in greater or less proportion, with the octaedral kind; and this latter became, in that case, less attractable, in proportion as the former species was more abundantly mixed with it. Those who have been accustomed to examine this species, and are in the habit of using a lens, (without which many interesting objects in mineralogy escape our observation,) may become capable of distinguishing it in the ore; and this faculty may perhaps hereafter be of great importance, provided it should be found that the quality of the iron obtained from the ore, is affected by the abovementioned mixture. If we scratch with a knife such specimens as contain both the abovementioned species, we may, indeed, by the appearance of a red powder, discover the particles of the cubic oxide, (which particles, if separated, would not be attractable,) and we may thereby, in some measure, estimate the proportion of the above oxide in the ore.

Fig. 1.

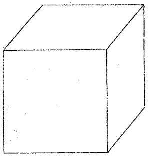
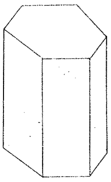


Fig. 2.



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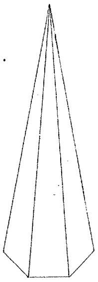

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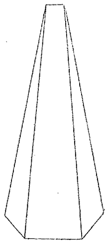

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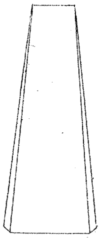

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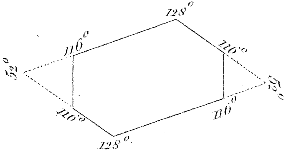

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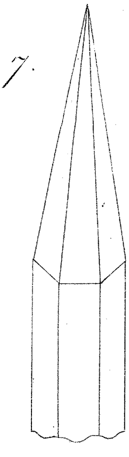

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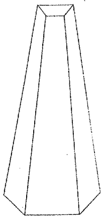

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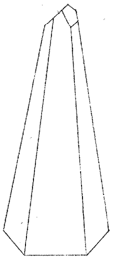
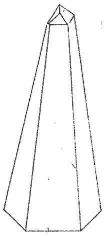


Fig. 10.



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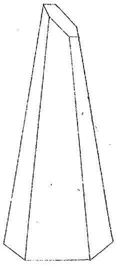

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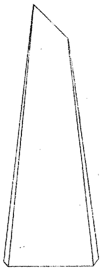

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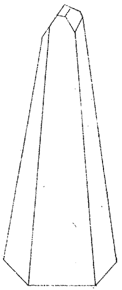

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