XXV. Description of the arseniates of copper and of iron

Count de Bournon Smith Barton M.D.

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where improvements are still very imperfect, it cannot be deemed a trivial task to have pointed out some of those vegetables from which an injurious honey is obtained.

The ancients, who, in some respects at least, were equal to the moderns, appear to have paid much attention to this subject. Virgil* and Columella have both told us what plants ought to grow about apiaries. It is unnecessary to repeat, in this place, what the two Roman writers have said on the subject. The *Georgics* of the Mantuan poet are in the hands of every man of taste; and the work of Columella† *should* be read, wherever agriculture engages the attention of gentlemen.

The proper management of bees may be considered as a science. It is not sufficient that bees merely make honey and wax. Their honey may be injurious or poisonous, and their wax may be nearly useless. To assist and to direct the labours of these little insects, the knowledge and the hand of man are required. Let, then, this interested being be at least attentive to his own benefits and pleasures. Let him carefully remove from about the habitations of his bees every fetid or poisonous vegetable, however comely its colour or its form. In particular, let him be careful to remove those vegetables which are noxious to himself. In place of these, let him spread the "marjoram and thyme," and other plants, "the love of bees‡," and his labours will be rewarded. He may, then, furnish his table with an honey not inferior to that of Mount Hermettus, or of Athens; nor to that of Sicily, to which Virgil has so handsomely alluded in the seventh Eclogue:

Nerine Galatea, thymo mihi dulcior Hyblæ,
Candidior cypnis, hederâ formosior albâ. L. 37, 38.

XXV. *Description of the Arseniates of Copper and of Iron.*
By the Count de BOURNON.

[Concluded from p. 12.]

THE modification which we have just seen the primitive crystal assume at one of its solid angles, and only on one side, sometimes takes place also (only on one side) at its two other angles. Then, if the act of crystallization has continued so long, under the same mode of increase, that the new

* See *Georgicorum* lib. iv. l. 30—32.

† *De Re Rustica*, libri xii.

‡ *Armstrong*.

edges, as AB, (fig. 15.) produced by the replacing of the solid angles, unite together, and give birth to a new equilateral triangle, placed in a direction contrary to the primitive one; and if, at the same time, the crystal has such a length that the secondary planes terminate at the opposite base, and are very acute isosceles triangles, the crystal will present the appearance of a kind of truncated hexaedral pyramid, the base and apex of which will be equilateral triangles. (fig. 18. Pl. IV.) The six triangular planes which compose the pyramid of this crystal, are always acute isosceles triangles; but three of them have their acute angle much smaller than the three others. The sides of the base of this kind of pyramid are opposite to the least acute angles; and its truncated apex is opposite to the most acute ones; the triangular planes being placed alternately in an opposite direction. I have seen several instances of this form; but I never saw such intermediate varieties as the secondary plane, represented by the dotted lines in fig. 15. would give, if it existed at the same time in the three angles.

By a longer duration of the act of crystallization, under the same modification, the plane corresponding to the truncated apex of the pyramid (fig. 18.) becomes progressively smaller; the most acute isosceles triangular planes, which answer to the secondary ones, encroach on the least acute, all which are the primitive planes of the crystal, and the pyramid becomes truly triedral at its upper extremity, whilst it remains hexaedral at the base, on account of those parts of the three planes of the primitive crystal which are still preserved. (Fig. 19.)

By a still more considerable duration of the act of crystallization, the pyramid would become completely triedral, and would not be truncated at its apex. I have never met with this modification so complete; but I have seen the variety represented in fig. 19; which, however, as well as fig. 18. is very uncommon.

The triedral prism is subject to a fourth modification, which takes place at the three edges of one of its two bases or terminal surfaces only, and replaces each of those edges by a plane, much more inclined on the side of the prism on which it is placed than on the terminal surface. (Fig. 20.) I have not been able to determine, in these crystals, the angles formed by these new planes, either with the sides of the prism or with the terminal surfaces; but the varieties belonging to this modification demonstrate that these angles are the same as those which the secondary planes of the solid angles make, either with the terminal surfaces, or with the edges

edges of the prism on which they are inclined. When these new planes have acquired an increase of sufficient extent to make the primitive planes of the prism totally disappear, and to replace them, the crystal is changed to a trihedral pyramid with a truncated apex; the base and truncated apex of which are equilateral triangles. (Fig. 21.) When it happens that the crystal has, at the same time, gone through this modification and that which replaces the solid angles of its other extremity, and these two modifications have commenced at the very origin of the formation of the crystal, there is a particular period of its progress, in which the crystal is lengthened into a hexahedral prism, with acute triangular isosceles planes, having for their bases two equilateral triangular planes, perfectly equal. (Fig. 22.) After this period, if the act of crystallization continues, the crystal assumes the appearance of an extremely acute rhomboid, the acute solid angles of which are replaced, more or less completely, by an equilateral triangular plane, (fig. 23.) and finishes at last by taking the form of a perfect rhomboid. (Fig. 24.)

All these varieties, though less common than those of the first modification, are yet frequently to be met with, excepting that of fig. 22. which is extremely rare, and of which I have seen only two or three crystals: in general, however, the crystals of these varieties are very small, and their form cannot be well seen without the assistance of a magnifying glass.

It frequently happens that two of the elongated trihedral prisms (fig. 10.) are closely united to each other by one of the sides of the prism; whence results a kind of macle (fig. 25.) the form of which is a rhomboidal tetrahedral prism of 60° and 120° ; but there is always discernible, on the terminal surfaces of these prisms, a very fine transverse line, AB, on the small diagonal of the rhomboidal plane of these surfaces; this line shows the place of union of the two crystals of which the macle consists.

Sometimes the two component crystals of this kind of macle belong to the trihedral prism, which has a secondary plane in the place of one of its edges; it then has the form either of a hexahedral prism that has four of its sides (two and two in opposition) broader than the others (fig. 26.), or of one that has only two opposite sides broader (fig. 27.), or of a regular one, according to the width of the secondary planes: in all these forms, the line AB, indicating the place of union of the two crystals, is perceptible.

It is not very common, as I have already observed, to meet

meet with specimens of this species in which the crystals are sufficiently detached to let their form be distinctly seen. In general, the crystals are grouped together in great numbers, and seem to penetrate each other, so as to form mamillæ, more or less round; or they form a kind of indented cylinders, which have some resemblance to the trundle of a mill. In that case, the part of the crystals which appears at the surface of these aggregations, commonly belongs to one of the sides of their prism, either the broad or the narrow one. But, when these aggregations form either a kind of cylinders, or of mamillæ in clusters diverging like a fan, there may be seen, at the two edges of the cylinder, or at the summit of the clusters, the whole of the equilateral triangular terminal planes, or trapezia, of one part of the component crystals.

The specific gravity of this species of arseniate of copper is nearly the same as that of the preceding one; I found it to be 4.280. Its hardness, however, is not so great; it is with difficulty that it can be made to scratch calcareous spar.

The crystals of this species, when they have not undergone any change, are transparent, and of a very beautiful blueish-green colour, or deep verdigrise; but their surface easily becomes decomposed, and turns black; the crystals are then totally opaque. It is indeed very seldom, and only in cavities recently exposed, that crystals can be found which retain their transparency and colour. Yet, as the change they undergo commonly takes place only at the surface, rarely penetrating to any great depth, their original colour may easily be restored, merely by slightly scraping the surface with a sharp instrument.

The above is the only change I have had occasion to remark in this species.

Sometimes, but very rarely, this species is found in the form of small hair pencils, with very delicate fibres; and as, in the specimens in which I observed this variety, the little fibrous tuft had preserved its beautiful verdigrise colour, nothing could exceed the beauty of their appearance.

I have likewise observed this species in a mamillary form, with a compact texture; but this variety, like the preceding, is extremely rare.

The matrix of this arseniate of copper is the same as that of all the preceding species; and that species which is most frequently found with it, is the arseniate in obtuse octaedra. It is also frequently accompanied with that kind of ore which is known by the name of *azure copper ore*.

SECTION II.

Arseniates of Iron.

Muttrell mine, which is immediately contiguous to Huel Gorland mine, in the county of Cornwall, has produced some specimens of arseniates of copper exactly similar to those described in the former part of this paper. But this mine is still more interesting to mineralogists, on account of a combination found therein, of arsenic acid with iron, and also a double combination of that acid with both iron and copper.

The first-mentioned of these arseniates seems analogous to those crystals, or cubes, of a fine green colour, of which some specimens had already been found in Carrarach and Tincroft mines, and which Klaproth, in his Memoir upon the Mineralogy of Cornwall, considered as belonging to the arseniates of copper; but, according to the analysis made by Mr. Chenevix, with all the care which his extensive knowledge and extreme zeal for science would naturally lead him to employ, it appears to be a true arseniate of iron, containing only a small quantity of copper; and even that quantity seems to be merely an accidental mixture. As, in the specimens from the old mines of Tincroft and Carrarach, the greatest part of the crystals adhered to vitreous gray copper ore, it is possible that some particles of that ore remained attached to the crystals; or, as I have frequently found to be the case, that some such particles had penetrated into the crystals, and that Mr. Klaproth had been thereby deceived, by finding in the button left by the blowpipe a much greater proportion of copper than this ore really contains. The natural decomposition of this arseniate, which produces an oxide of iron of a fine reddish yellow colour, strongly confirms the result of Mr. Chenevix's analysis.

Gmelin, in his Principles of Mineralogy, printed at Göttingen in the year 1790, had already supposed that these crystals could not belong to the substance which, in mineralogical publications, had been called *arsenical copper ore*. He had consequently separated them, leaving them, however, among the ores of copper, under the name of *würfel erz*.

The double combination of the arsenic acid with iron and copper, although it had appeared to exist in the arseniate just spoken of, in the mines of Tincroft and Carrarach, had not excited the attention of mineralogists. It is however possible that the transparency, the brilliancy, and the pale blue colour of its crystals, might occasion them to be mistaken for crystals of a stony nature. Besides, their smallness might easily

easily cause them to escape the notice of common observation, particularly when they are not in pretty large groups.

The matrix of these two arseniates is exactly the same as that of the arseniates of copper; consisting, like that, of quartz, mixed with yellow, gray, and vitreous ores of copper, with oxides of iron, and with mispickel. The mines of Huel Gorland and Muttrell, although not situated in the district of the tin mines, have yet produced some specimens of tin, the crystals of which are covered with those of the arseniate here spoken of. Two specimens of this kind are in the collection of Sir John St. Aubyn.

Species I. *Simple Arseniate of Iron.*

This species crystallizes in perfect cubes, (fig. 28.); sometimes, though rarely, they are a little flattened; their sides are smooth and brilliant.

The only modification I have observed in this form is, that four of the eight solid angles of the cube are replaced by an equal number of equilateral triangular planes, situated in such a manner, that every one of the sides of the cube becomes an elongated hexagon, having two angles of 90° each, and four of 135° . (Fig. 29.) Crystals modified in this way are very scarce. I have never seen but one such specimen, which is in the collection of Sir John St. Aubyn. The crystals of it are pretty large, and very well defined.

The specific gravity of this species is 3,000. Its hardness is just sufficient to scratch calcareous spar. Its crystals, which are tolerably transparent, are of a dark green colour, with a brownish tinge; sometimes they are rather yellowish; and there exist some specimens of a brown yellow colour like resin. I have never seen this species in any other state than that of perfect crystallization.

Sometimes, indeed, a decomposition takes place, which causes the crystals to pass into the state of a pulverulent oxide, of a fine reddish yellow colour. In this case, as the bulk of the crystals is considerably diminished, there is perceived, upon breaking them, a considerable number of small cavities in their substance. These cavities are analogous to those which appear in the crystals of the spathose ores of iron when they have passed into a similar state of decomposition.

Species II. *Cupreous Arseniate of Iron.*

The crystals of this species are of uncommon brilliancy, and are perfectly transparent. Their form is a rhomboidal tetraedral prism, having two of its edges very obtuse, and the other two very acute: but, owing to the minute size of these

these crystals, I have not yet been able to determine the measure of their angles. The prism is terminated at each of its extremities by a tetraedral pyramid, which is pretty sharp; and its planes, which are scalene triangles, unite by pairs, forming elongated ridges, which join the acute edges of the prism: in the other direction, they unite, also by pairs, so as to form a ridge which is less elongated, and joins the obtuse edges. Very often the obtuse edges of the prism are replaced by planes (of greater or less extent) equally inclined upon the adjacent ones. (Fig. 31.) Sometimes the acute edges are also replaced in the same manner, but always by planes of less extent. (Fig. 32.)

The above are the only varieties I have observed of this arseniate. Its crystals seldom occur singly, being generally grouped together, in a very irregular manner; sometimes, however, they are so united as to assume a mamillated form, having the pyramids of the crystals which compose the mamillæ all placed upon the surface thereof.

The specific gravity of this arseniate is 3,400.

Its hardness is rather greater than that of the simple arseniate of iron: it scratches calcareous spar with greater facility, but does not scratch fluor spar, or heavy spar.

Its colour is that of a very faint sky-blue; sometimes the blue colour is a little deeper. I have seen some crystals which had the same brown resin colour as the preceding species; but they are very rare.

Hitherto I have never met with this species in any other form than that of a perfect crystal.

XXVI. *Analysis of the Arseniates of Copper and of Iron.*
By RICHARD CHENEVIX, Esq. F.R.S. M.R.I.A.*

SECTION I.

Arseniates of Copper.

THE endless diversity which the hand of Nature has diffused through all her works, even when she makes use of the same primitive materials, must sufficiently convince us, that, whatever accuracy we may attain in the knowledge of the latter, the means which she employs to form her combinations are still secret. The intellectual eye may indulge in the contemplation of hypothetic systems, which itself has created, and which it alone can behold; but how far removed

* From *Transactions of the Royal Society of London* for 1801.

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