X. *Description of the Arseniates of Copper, and of Iron, from the County of Cornwall. By the* Count de Bournon. *Communicated by the Right Hon. Sir* Joseph Banks, *Bart. K. B. P. R. S.*

Read February 19, 1801.

SECTION I.

ARSENIATES OF COPPER.

THE natural combination of the arsenic acid with copper, and the different aspects under which this combination appears, according to the proportions in which these two substances are united, were among those objects of mineralogy, respecting which our imperfect knowledge required the aid of study and observation. A new copper mine, lately worked, called Huel Gorland, in the parish of Gwennap, in the county of Cornwall, having, within the last two years, enriched the cabinets of London with some very fine specimens of these arseniates, I have been induced to pay particular attention to them; and I offer the result of my observations to the Royal Society, as an acknowledgment of that gratitude which I and all Frenchmen, faithful to their king, ought to feel and profess to a country which has distinguished itself as the protector of honour and loyalty.

Although there appears, according to some German authors, reason to think that arseniate of copper has been found in Silesia, its much greater abundance, as well as the various

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aspects under which it exists, in the county of Cornwall, may entitle it to be considered as one of the many mineral substances which are peculiar, or nearly so, to England.

Of the various works on mineralogy lately published, there are few which have not mentioned arseniate of copper, among the ores of this metal. It seems, however, that some of their authors had no knowledge of this ore, except from the very imperfect account communicated by the celebrated KLAPROTH, in 1787, in the *Schriften der Gesellschaft Naturforschender Freunde,* Vol. VII. in which he has given an interesting sketch of the mineralogy of the county of Cornwall, as far as it was then known. Others seem to have possessed only imperfect specimens of arseniate of copper, as none of the forms which they attribute to its crystals, can belong to it. Besides, they all confound with this ore, those cubic crystals, of a very beautiful green colour, which are found in Muttrell mine, contiguous to Huel Gorland mine; and which, according to the analysis made with the greatest care and ability, by Mr. CHENEVIX, are of a nature totally different, and cannot properly be classed among copper ores, as they contain but a very inconsiderable quantity of that metal.

The existence of arseniate of copper seems, however, even at this day, to be an object of doubt among the French mineralogists; for the Abbé HAUY does not mention it in the 28th and following numbers of the *Journal des Mines,* although they contain an interesting extract of a system of mineralogy, which he was then preparing for the press; nor has M. FOURCROY even hinted at it, in his *Système des Connoissances Chimiques,* lately published.

It is now above twenty years, since arseniate of copper was discovered in the county of Cornwall; it was first found either in Carrarach mine, in the parish of Gwennap, or in Tincroft mine, in the parish of Allogan. Its matrix, like that of almost all the copper ores of this country, was siliceous, and consisted of a decomposed granite, of which the greatest part of the feldspar had passed into the state known by the name of *Kaolin*. It was accompanied with grey vitreous copper ore, frequently in considerable masses; also with much black oxide of copper; and with various oxides of iron.

The arseniate here spoken of, which had never been found in large quantity, had ceased to exist in the above-mentioned mines, when Huel Gorland mine, lately wrought, began to enrich mineralogy with this uncommon substance. The matrix of this is likewise siliceous; sometimes crystalline; and sometimes in an amorphous mass. Here and there we find mixed with it, in greater or less profusion, all the known oxides of copper; many of the argillaceous oxides of iron; also grey vitreous copper ore; arsenical pyrites; and the rich deep-coloured yellow copper ore. This last is often found differing from its usual appearance, in a manner which I believe has not hitherto been taken notice of. I think it should make a distinct variety among the deep yellow copper ores, under the name of *yellow hematitic copper ore*.

When the combination of copper with iron and sulphur is rich in metal, (for when it is poor, it is only a martial pyrites mixed with a little copper,) its appropriate colour, when a piece is fresh broken, is a deep yellow; and this yellow colour is more deep, in proportion as the quantity of copper is more abundant. In its richest state, it assumes a more or less greenish tint. The surface of a fresh fracture is very brilliant, and appears rather uneven, as if composed of small laminæ, crossing one another in an irregular manner. When it begins to decompose, its surface is covered with the most beautiful colours; among which the most predominant are, violet, blue, and green: this has caused it to be compared to a pigeon's breast. When these colours are very deep, and occupy the whole surface of a piece, we commonly perceive here and there, some little points, in the state of red oxide of iron; and others of a green colour, in the state of green carbonate of copper.

This kind of copper ore is sometimes of a deep yellow colour, which inclines the more to green, as it is destitute of brilliancy. It is very compact, and, when broken, the fracture appears smooth, sometimes a little conchoidal; its surface, however, has a very fine grain, which, when viewed with a powerful lens, resembles the aggregation of a very close compact mass of the finest sand. Its most usual texture is that of thin layers or plates, lying one upon another, and being very closely united, so as to be scarcely perceptible to the naked eye; but they are very readily distinguished with the lens. These layers, however, do not adhere very strongly, as they may always be separated by the stroke of a hammer.

This ore frequently assumes a mamillated form; the mamillæ being of different dimensions, from the size of a man's head, and even larger, to that of a small pea. In the latter case, the mamillæ are very often united, as in that kind of iron ore which is called cluster, botryoid, or kidney hematites. Sometimes the surface of the mamillæ is covered with small points; but more frequently it is smooth, so as very much to resemble a piece of polished metal; and, as the surface of the mamillæ inclines rather to a brown colour, they have the appearance of antique bronze. The green oxide of copper which sometimes is observed on it, completes the illusion, by assuming the aspect of that fine patina which often covers pieces of antique bronze.

This ore is likewise found in the form of small cylinders, often placed one against the other, and sometimes ramified, in the same way as is observed in some kinds of hematites. When the broken surface of it is exposed for some time to the air, it assumes the colour of tarnished gold. It acquires also, by the decomposition of its surface, the same violet, blue, and green colours as the kind already described; but, although these colours are frequently very deep, they never are so brilliant as in that kind.

It is very uncommon to find pieces of this ore that are not mixed, and frequently even penetrated, with grey vitreous copper ore. That which accompanies the arseniate of Huel Gorland mine, offers, in this respect, an uncommon and very particular appearance. The yellow ore is mechanically mixed with the vitreous ore, so as to form a compound, in which, by the assistance of a lens, the small particles belonging to each of those two ores, may be very clearly distinguished. The specific gravity, as well as the quantity of copper, in this ore, varies considerably, according to the proportions in which the yellow copper ore and grey vitreous copper ore are mixed together; sometimes they seem to be mixed in equal proportions, or nearly so.

Nature has established very remarkable differences between the arseniates of copper; and these take place not only in their forms, but likewise in their hardness and specific gravity. These differences arise, either from the manner in which the arsenic acid is combined with the copper, or from the different proportions in which these two substances are combined. I have been naturally led to follow the same order, and to divide the arseniates of copper into four different species: and the very interesting analysis of this substance, made by Mr. CHENEVIX, has afforded me the most satisfactory sanction to this division. It is thus that the chemist and the naturalist, by freely uniting their labours, without jealousy or prejudice, ought in all cases to proceed, in order to attain that certainty which is the desirable recompense of their endeavours.

FIRST SPECIES. *Arseniate of Copper in the form of an obtuse octaedron.*

The most simple form under which this species appears, is a very obtuse octaedron, formed by the united bases of two tetraedral pyramids, with isosceles triangular planes; and this appears to be its original form. This octaedron has, in each of its pyramids, two opposite planes more inclined than the other two; which gives a parallelogrammic form to their common base. (Fig. 1. Plate XIII.) The two planes more inclined than the others, meet at the apex of each of the pyramids, in an angle of 130°; and at the common base, in one of 50°. The two planes which are less inclined, meet at the apex, in an angle of 115°; and at the base, in one of 65°.

These planes are commonly smooth and bright; sometimes, however, they are striated, in a direction parallel to their edges.

The four planes seldom terminate in one and the same point: more commonly the apex is formed into a ridge, the octaedron being lengthened, parallel to its less inclined planes; the base is then a square, or at least approaches very nearly to that form. (Fig. 2.)

These two varieties are the only ones I have observed in the form of the crystals of this species, although I have had the opportunity of examining a great number of specimens.

This arseniate is very light; its average specific gravity, taken on six pieces perfectly pure, was 2,881. Its hardness is likewise very inconsiderable; it easily scratches calcareous spar, but makes no impression on fluor spar.

It is seldom perfectly transparent; but has generally a cloudy aspect.

The usual colour of this species (for this character is as essential in metallic substances as it is immaterial in stones) is a beautiful deep sky-blue; sometimes, but very rarely, it inclines more or less to Prussian blue. It is frequently of a very fine grass-green; the crystals have then a much more beautiful transparency. I have seen some which were of a fine apple-green; others white, having a slight blue cast. In one piece, the crystals of which were of a green colour, and less transparent than they commonly are, I discovered, on breaking them, that the colour of their central part, for about half their thickness, was blue. From the observations made by Mr. CHENEVIX, in his analysis of these arseniates, it appears that the variation in their colour, principally depends on the quantity of water, which enters as a constituent part into their formation.

This species is found mixed with all the other kinds of arsenical copper ore; but that which most commonly accompanies it, is the prismatic triedral species.

I have never discovered in this species, any thing which could induce me to suppose it susceptible of decomposition, or even of change.

SECOND SPECIES. *Arseniate of Copper in hexaedral laminæ, with inclined sides.*

This species is commonly found in very fine hexaedral laminæ. The six narrow sides of these laminæ have an inclined position, alternately in a contrary direction, on the two broad planes, in such a manner that each of the planes is encompassed by three sides, which are inclined upon it. (Fig. 3.) As far as the small size, and more particularly the thinness of these crystals, has enabled me to judge, two of these three inclined sides, form an angle of about 135° with the broad planes on which they incline; and the third, one of 115°.

The two broad planes are smooth, and have a very brilliant lustre. The six narrow sides are rendered very dull, by the great number of striæ with which they are covered; most of which are very prominent, and all are parallel to the edges of the broad planes. In consequence of this, these crystals may be divided, parallel to the planes, almost as easily as crystals of mica.

This structure prevents the crystal from being considered as a modification of the octaedron: that which would be produced by an increase of the inclined sides, would only be a secondary crystal; and none of the specimens I have seen, give mereason to suppose the existence of such a variety.

The colour of this species is a fine deep emerald green; sometimes, though rarely, it is found of a lighter colour. The lustre of its broad planes, which are the only parts of the crystal that forcibly strike the eye, give it pretty much the appearance of those coloured metal plates which are known by the name of foil.

This species is still less heavy than the preceding; its specific gravity being only 2,548.

It is also less hard; it easily scratches gypsum, but not calcareous spar.

When its crystals are very thin, they are very transparent; but their transparency is diminished when they have any degree of thickness.

When exposed to fire, this species decrepitates very strongly.

This arseniate, the matrix of which is generally quartzous, is occasionally found mixed with some other arseniates of copper, and particularly with the acute octaedron in the capillary or fibrous state. (Spec. 3. Var. 1 and 2.) But the ore most commonly found with it, is the red copper ore, which is frequently very abundant.

I have never observed in this species any appearance of decomposition.

THIRD SPECIES. *Arseniate of Copper in the form of an acute octaedron.*

The most simple form in which this third species is found, is likewise an octaedron; but this octaedron, instead of being obtuse, like that of the first species, is slightly acute. It has, like that, in each of its pyramids, two opposite planes more inclined than the other two. The more inclined planes meet at the apex, in an angle of 84°; and at the base, in one of 96°: the other two meet at the apex, in an angle of 68°; and at the base, in one of 112.° (Fig. 4.)

In this octaedron it sometimes happens, that the planes which compose its pyramids tend to one and the same point, in order to form the apex; but it is much more common to find it extended in a line parallel to the less inclined planes of the pyramid. (Fig. 5.) The crystal is still more frequently found in the form of a long tetraedral rhomboidal prism, of 84° and 96°, terminated by a diedral apex, with isosceles triangular planes, which are placed on the angles of 84°, and meet in an angle of 112°. (Fig. 6.)

Most commonly, both in the perfect and the lengthened octaedron, the angles of 96° are replaced by a plane, which is equally inclined on the adjacent sides, (Fig. 7.) and is frequently very broad: (Fig. 8.) then the tetraedral prism of 84° and 96°, is changed into a flat hexaedral prism, having two angles of 84°, and the other four of 138°. I never saw the angles of 84° replaced.

The average specific gravity of this arseniate of copper, taken on five pure pieces, was 4,280.

It is sufficiently hard to scratch fluor spar; but is not hard enough to scratch glass.

Its usual colour is a brown, or bottle green, so dark that the crystals appear of a blackish colour, when they are not opposed to the light; sometimes, but very seldom, in the regular crystals which happen to be rather thicker, this colour is a clearer green; in other specimens, the crystals have a yellowish cast, and the surface then often reflects the light of a golden tint.

The transparency of this species is generally pretty great.

It is not always crystallized in a determinate form, but is an absolute Proteus, both with respect to the different forms in which it appears, and the various colours it exhibits. I have observed the five following varieties of it.

Variety 1. *Capillary, of a determinate form.*

In this variety, the crystals are extremely slender, yet preserve their form, which is that of a very lengthened octaedron. The small slender crystals often form themselves into a confused group; sometimes, however, they form small mamillæ, by the divergence of a number of them from a common centre. Their colour is either a fine grass green, or a yellowish green, or a golden yellow; and they have generally a beautiful transparency.

Variety 2. *Capillary, of an indeterminate form.*

In this variety, the very thin needle-like crystals are not terminated by the diedral apex of 112°, representing two planes of the octaedron, but gradually become smaller, and terminate in a very sharp pyramid. This variety has the same colours as the preceding; and its very slender crystals are grouped in the same manner as in that.

Substances in a crystallized state, in passing from a determinate form to an indeterminate or fibrous one, frequently assume an intermediate form, in which the crystal insensibly terminates in a very acute pyramid.

Variety 3. *In crystals perfectly regular for a part of their length, and fibrous at their extremity.*

In this variety, the crystals are perfect during a part of their length; but their substance insensibly divides as it approaches the extremity, which very often is in fact nothing but a cluster of extremely delicate fibres, the colour of which always appears lighter than that of the solid part of the crystal.

Variety 4. *Amianthiform.*

This variety is composed of fibres as delicate as those of amianthus, of the flexibility of which they frequently possess a certain degree. These fibres are either parallel, or divergent from one common centre, in which case they nearly resemble a hair pencil. Their colour varies considerably: I have seen them of different shades of green, from a grass green to a dark brown green, of a golden brown, of a straw colour, of a golden yellow, of a greenish blue colour, and even perfectly white, having frequently the lustre of satin.

The fibres are sometimes so delicate, so short, and so confusedly grouped together, that the whole appears like a dusty cottony mass, the true nature of which is discoverable only by the lens. At other times, this variety appears in small thin laminæ, rather flexible, sometimes scarcely perceptible to the naked eye, sometimes tolerably large, and perfectly like *amianthus papyraceus.* I have seen the last mentioned form of this variety, of a light green colour, and also of a very delicate white.

Variety 5. *Hematitiform.*

This variety is in layers, either flat or mamillated; and is of a fibrous texture; but is rendered compact by the close manner in which the fibres are united to each other, in the same way as is observed in many martial hematites, and more particularly in that kind of tin ore which is known by the name of woodtin, to which, some pieces of this arseniate of copper have a very great resemblance. Yet it sometimes happens, as in many aggregate pyrites of a globular form, that the surface of the small mamillæ is covered with little rough points: these are the diedral apices, which terminate the little crystals supposed to contribute to their formation.

This hematitic variety is found with the same diversity of colours as the preceding, or amianthiform variety.

FOURTH SPECIES. *Arseniate of Copper in the form of a triedral prism.*

The primitive form of this species is a triedral prism, the bases of which are equilateral triangles; (Fig. 9. Plate XIV.) this prism is often considerably lengthened, in a direction parallel to one of its bases. (Fig. 10.) This form is one of the most rare in crystallography. The crystals have all their sides smooth and brilliant; yet there are observable in some of them, when examined with a magnifying glass, transverse striæ on the sides of the prism, all of which are parallel to the edges of the bases. It is, therefore, chiefly on the planes of the bases, that the crystalline laminæ appear laid upon one another, to produce either the increase or the modification of the primitive crystal.

As the crystals of this species are seldom sufficiently detached to be easily perceived, and indeed are very frequently so small as to escape the observation of the naked eye, I think it necessary to describe here all the various forms in which I have seen them, with the progress observed in their passage from one form to the other, however small the difference between these forms may appear. Such a description will lead to a better knowledge, not only of the primitive crystal itself, but also of those forms of it which seem to be the most distant from its original one.

Very frequently, the triedral prism passes to a tetraedral modification, by the simple replacing of one of its edges by a plane, equally inclined on the adjacent ones. This plane is either very narrow, (Fig. 11.) or of a more considerable width. (Fig. 12.) Sometimes the width of the plane is such, that it reduces the primitive adjacent planes to extreme narrowness. (Fig. 13.) In this last case, the crystal appears under the form of a rectangular plate or lamina, having two of its narrow opposite sides or planes inclined, in one and the same direction, on one of the two broad planes. It sometimes happens, in this variety, that the two broad opposite planes approach more or less to a square form. (Fig. 14.) I have also seen some crystals, in which the two other edges of the prism seemed to have likewise very slight secondary planes; but, when that happens, they are always very narrow, especially when compared with the secondary plane of the third edge. This modification, in its various forms, is the most common one of this species.

Sometimes one of the solid angles of the triedral prism is replaced, on one side only, by a plane that is much inclined to the edge of the prism on which it is situated; but the crystals are always too small to admit of being measured with precision. (Fig. 15.) This plane, assuming a more considerable extent, replaces the same edge of the prism by another plane, much broader at one extremity than the other, as is shewn by the lines of large dots in the same Figure. Sometimes it has a very considerable extent, as is represented in Fig. 16. It then reduces one of the bases of the triedral prism to the form of a very narrow trapezium, while that of the opposite base remains very broad. By a still more considerable increase, the plane of this base totally disappears; and the crystal is terminated, at that extremity, by a ridge. (Fig. 17.) In this variety, the crystal is often seen placed upon one of its scalene triangular sides, and then presents the other at its upper extremity; an appearance which is apt to puzzle the observer, particularly when he perceives, among the triangular sides which most generally terminate the crystals, nothing but equilateral triangles. This modification, in all its forms, is much less common than the preceding one; it is, however, occasionally met with.

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 edges, as A B, (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.) 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 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 triedral 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 hexaedral 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 triedral 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 tetraedral prism, of 60° and 120°; but there is always discernible, on the terminal surfaces of these prisms, a very fine transverse line, A B, on the small diagonal of the rhomboidal plane of these surfaces; this line shews 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 triedral prism which has a secondary plane in the place of one of its edges; it then has the form, either of a hexaedral 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 A B, indicating the place of union of the two crystals, is perceptible.

It is not very common, as I have already observed, to 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 bluish 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 grey 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 blow-pipe, 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 Gottingen, 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 ertz.*

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 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, grey, 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. Plate XV.) 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 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.

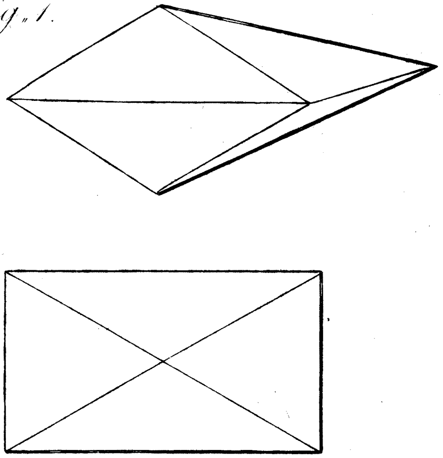
The specific gravity of this arseniate is 3,400.

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.

Fig. 1.



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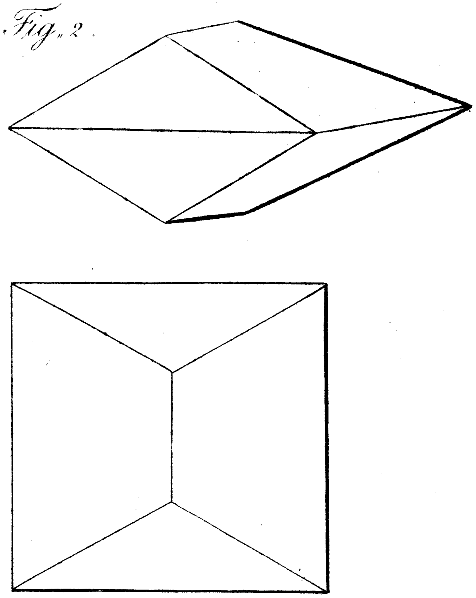

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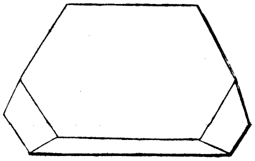

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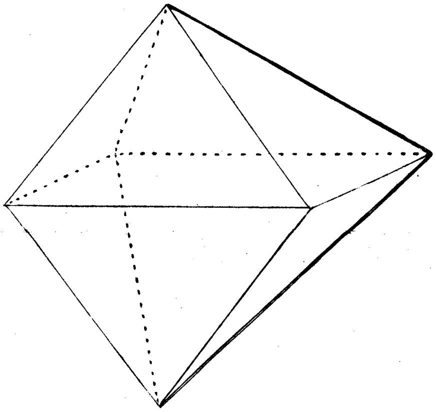

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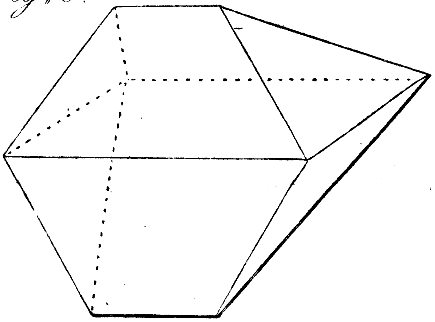

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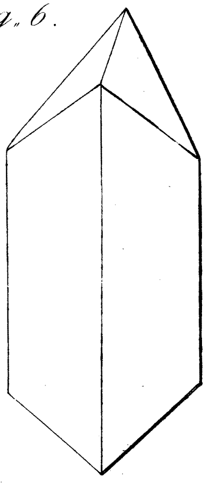

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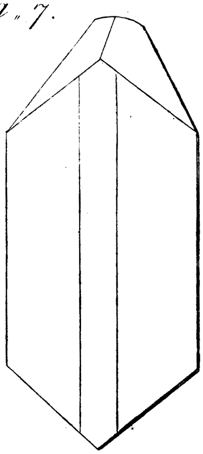

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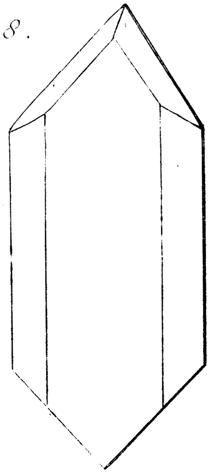

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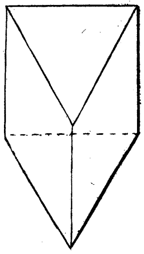

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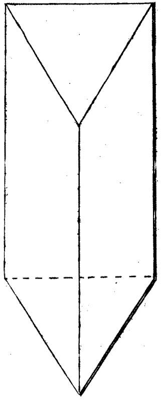

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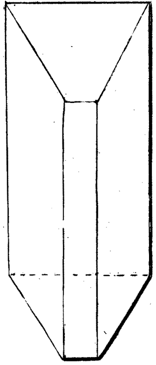

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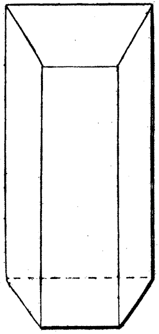

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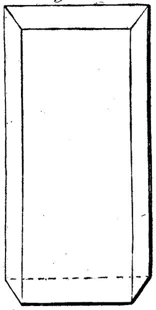

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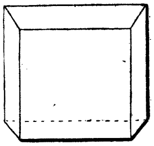

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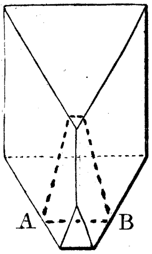

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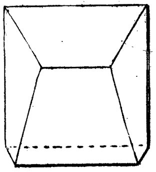

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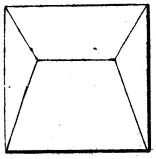

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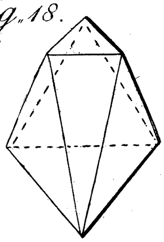

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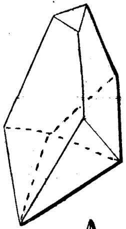

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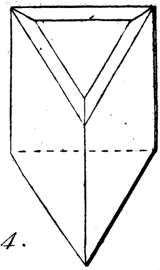

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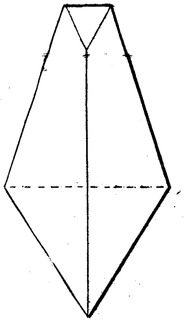

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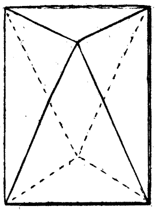

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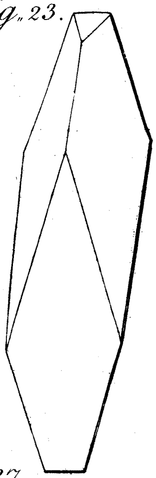

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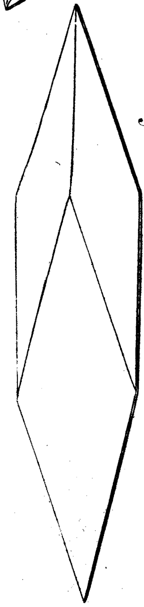

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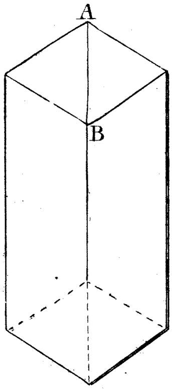

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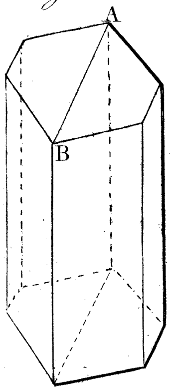

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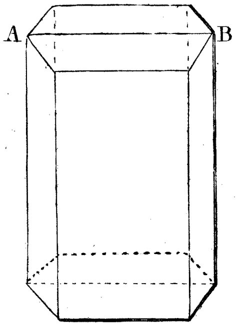

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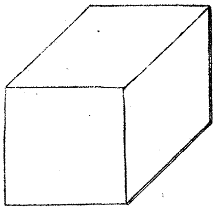

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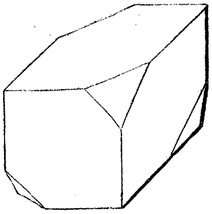

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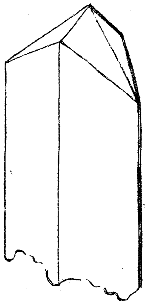

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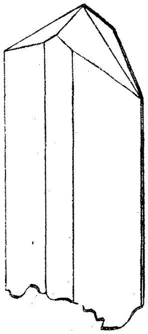

Fig. 32.