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times eggs, potatoes, &c. We had an uncommonly pleasant voyage home, and constant fine weather, accompanied with northerly breezes.

We arrived about the latter end of August safe in Greenland Dock, after having been out five months.

Captain Souter kept an excellent table in the cabin, and a constant fire in the stove: his study was to make every person on board comfortable. In the fifteen voyages I have been to sea, I have only twice had the good fortune to sail with men of equal worth; Mr. Charles Patterfson of the Sea Horse, and Mr. William Alder, now a Lieutenant in the British Navy.

VI. *An Attempt to arrange the Crystals of Oxidated Tin Ore, according to their supposed Structure. By Mr. WILLIAM DAY, Leicester Place. Communicated by the Author.*

THE crystallisations of oxidated tin ore are described by Romé de l'Isle, in his Cristallography, to be of the octaedral form and its modifications; the octaedra having isosceles triangular faces, inclined at an angle of 45° to the base of each pyramid; so that the junction of their bases and apices are right angles. In the following arrangement the octaedron is considered as the primitive form, and the modifications as being produced by an accumulation, on its faces, of laminæ composed of similar minute molecuæ, experiencing different laws of decrement on their sides or angles, or on both. These laws of decrement are marked with the signs invented by Haüy, of which an account has been given in the Phil. Mag. Vol. II. p. 398. The greater part of these forms having been very accurately described by De l'Isle, all that is now attempted is an application of Haüy's system to the arrangement of this part of a private cabinet of English minerals; nor would it have been made public but for the repeated solicitations of several friends.

In

In the annexed drawing (see plate III.) all the plans, and also the figures marked *1 a*, *1 b*, and *1 c*, are geometrical: the others are drawings from models, and in perspective as they appear to the eye; but all of them placed in the same relative situation to the nucleus, fig. 1., on which they are supposed to be formed. Mathematical correctness is not attempted, nor is it necessary. The prisms are shewn with the pyramid on one end only; not on both, as in De l'Isle's plates.

Fig. 1, a perspective view of the primitive octaedron of oxidated tin ore. *1 a*, a front geometrical elevation, with the quantity of the angles marked upon them. *1 b*, an angular geometrical elevation, also with the quantity of the angles marked upon them. *1 c*, one of the faces of the octaedron, subdivided to shew the supposed arrangement of the primitive molecule that form one lamina. The dark triangles represent the spaces they occupy respectively, and the difference of shading, the progress of diminution by a subtraction of one range of molecule on the edges of the faces, according to the third law of decrement. The superior angle *A* of this face is 70° , the two inferior angles *E, E*, 55° each. The letters on the three geometrical figures mark the same situations on all of them, and are those employed by Haüy to indicate the laws of decrement.

As Haüy's *system* has been given in the First Volume of the Philosophical Magazine, and his *signs* in the Second, little more is required here but to give the sign to which the figures belong.

First Law of Decrement $\frac{1}{1}$.

To this law belong fig. 2, 3, and 4. Fig. 2 *a*, without the dotted lines, would represent a plan of fig. 2. That portion of fig. 2 *a*, included between the dotted lines *b b*, *b b*, represents a plan of fig. 3. The plan of fig. 4 is evident from the figure.

Second Law of Decrement $\frac{1}{2}$.

Fig. 5 belongs to this law: fig. 2 *a*, the angles being taken off at the dotted lines, represents a plan of it. Fig. 6 is a combination

Lowry sculp.

combination of this law with another not yet determined, making the prism sixteen-sided: fig. 6 *a* is the plan.

Third Law of Decrement $B \begin{smallmatrix} I \\ D \\ I \end{smallmatrix} B.$

Fig. 7 shews it incomplete. The plan is shewn, fig. 22 *a*, including the dotted lines. Fig. 8, the completion of this law: 8 *a* is the plan. Fig. 22 is an irregular formation, by this law taking place unequally: 22 *a*, (without the portion expressed by the dotted lines,) is the plan. The plans of two other unequal accumulations, which disguise the pyramid, are shewn fig. 7 *a*, 7 *b*. Fig. 21, the same as fig. 8, become cuneiform: 21 *a*, the plan.

Fourth Law of Decrement A.

Fig. 9 shews the combination with the first law: fig. 10, the same with the third law, incomplete: fig. 11, the last completed: fig. 12, the combination with the first and second laws: this, and the combination with the first law only, are in general peculiar to Bohemian and Saxon ores; the English ores exhibit but few examples of them. I have an English crystal similar to fig. 9, and it is the only one I have seen. Fig. 13, the combination with the second and third law: fig. 13 *a* is the plan.

Fifth Law of Decrement ${}^2E \begin{smallmatrix} I \\ D \\ I \end{smallmatrix} D.$

Fig. 14, the first indication of this law, in combination with the third law, incomplete. Fig. 15, this law farther extended in the same combination: 15 *a*, the plan. Fig. 16, a further extension, but still incomplete: fig. 16 *a*, the plan. Fig. 17, the completion of this decrement: fig. 17 *a*, the plan. Fig. 18, the combination of this law, when arrived at the stage shewn in fig. 16, with the third law. Compare fig. 15 and 18. Fig. 19 and 20 are the same as fig. 16, with some irregularity in the formation.

These five laws of decrement embrace all the varieties of facets I have yet observed (except those mentioned when speaking of fig. 6); and by combination, in different stages
of

of each respectively, produce a great variety of forms, while other varieties arise from difference in colour and transparency to which all these crystallisations are subject.

The macles of De l'Isle, which Hauy has called *hemitrope*, or half-turned, may be added as a supplementary class. Of the term *macle*, De l'Isle gives this explanation: "When in any crystal whatever one or more re-entering or internal angles are observed, we may conclude that it is not a simple crystal, but a group of two or more; or even two turned or reversed moieties of the same crystal." De l'Isle was indebted to a Mr. Lermina for determining the direction of the section which produced the hemitrope crystals of tin, which he has shewn to be parallel to two opposite edges of the octaedron. Imagine the primitive octaedron to be divided into halves by a plane passing diagonally through it, from the centre B, fig. 24, of one of the edges of the superior pyramid, to the centre B of that edge of the inferior pyramid which is diagonally opposite; the plane will pass through two opposite angles FE of the base, dividing on each pyramid two adjoining faces into four scalene triangles, and leaving two adjoining faces perfect, but reversed on one pyramid in respect to the other. The plane FBEB' of this section is a rhomb of 60° and 120° .

The prismatic crystals appear to be as susceptible of that species of accumulation which produces the hemitrope as the octaedron, and the section is always parallel to the one determined above. If the prism is short, and terminated by two pyramids, the section will pass through the prism into both pyramids, and be irregularly octagon; but if the prism is long enough to permit the section to pass through it without encroaching on the pyramids, it will be a rhomb of 70° and 110° ; the same as the section of the primitive octaedron, perpendicular from the apex, and diagonally across the base.

I have some crystals which are produced by a double section, and both ends turned on the middle part; others which appear to be only portions taken off the angles at the junctions

tions of the pyramids to the prism, and reversed together without the intermediate part. In fact, the varieties appear to be almost innumerable.

After I had made the above arrangement, I received the 32d Number of the *Journal des Mines*, from which I beg leave to subjoin the following extracts :

“ The primitive form of the crystals of oxydated tin appeared to me to be that of a cube performing the function of a parallelopipedon; so that the decrements which produce the secondary forms have, in regard to the two opposite faces of the cube, which must be considered as the bases, an action different from that which takes place in regard to the other four faces that represent the planes of the prism.” (p. 576.)

“ One of the rarest varieties of this kind is that represented fig. 7 *, and which is the seventh of Romé de Lisle, T. III. p. 422. We give it the name of *dislique* oxyd of tin; that is to say, with two ranges of facets. It has altogether thirty-six faces; four of which MM are vertical, and on each side eight inferior oblique z, z' , and eight superior oblique o, o' . If, as usual, we denote the edges of the base of the cubic nucleus by B, and the angles by A, we shall have, as the indicating sign of this variety, $M \left(\overset{\frac{1}{3}}{A} B^2 B^5 \right) \overset{\frac{1}{2}}{B} \overset{2}{A}$, in which the intermediary decrement is referred to the facets z, z' , the decrement $\overset{\frac{1}{2}}{B}$ to the facets s, s' , and the decrement $\overset{2}{A}$ to the facets o, o' . The following is the indication of the principal angles: incidence of M to M 90° , of z to z $116^\circ 20'$, of z to z' $158^\circ 30'$, of s to s 120° , of o to s 150° . Quantity of the angle n $118^\circ 4'$.” (*Suite de l'Extrait du Traité de Minéralogie de C. Haüy*, p. 578.)

From the preceding extracts it appears that Haüy has supposed the cube to be the nucleus or primitive form of the oxidated tin crystals. I have again carefully examined the crystals in my own collection, and, according to the indi-

* Fig. 23 is a tracing from Haüy's fig. 7, referred to here, and is the same crystal as represented fig. 18.

cations observed on them, from which I have formed my arrangement agreeably to the law laid down by Haüy himself, (see *Phil. Mag.* Vol. I. p. 292.) I see no reason at present why I should alter it. The crystals of oxidated tin are in general so hard and brittle that I have not been able to separate the laminæ; and there is nothing to guide the observer but the direction of the striæ on the secondary facets. Now the faces, which are parallel to the faces of the octaedron before mentioned, are always very brilliant; but those which are on a plane with the edges are striated parallel to those edges, particularly those crystals which shew the intermediate stages of the third law. If the nucleus were a cube, and the laminæ accumulated on it, to form the secondary crystals, shewed their direction by striæ on the new facets, those striæ would be in a direction quite contrary to what are shewn on these crystals: instead of going the length of the new facets parallel to the edges of the octaedron, they would cross the facets perpendicularly to their present direction, and it would be impossible for the crystal fig. 7 to take the form of fig. 8. In my collection there is a group of opaque black crystals, shewing all the variations from the primitive prismatic crystal fig. 2, to the completion of the third law of decrement fig. 8. In all of them the direction of the striæ is very evident. The Saxon and Bohemian ores of tin are most common in the cabinets of France: the crystals are larger, but do not present the varieties of forms that English ores do; being mostly confined to the octaedron and its hemitrope, and those variations of the fourth law which approach the cube. Had Haüy seen a greater number of the varieties of the English tin ores, I think he would, for the primitive form, have had recourse to the octaedron, which, by a very simple law of decrement, produces the cube and its varieties that occur in the tin crystallisations.

To these observations may be added De l'Isle's description of the same crystal that Haüy has described (above), which

I find

I find to agree so well with what I have observed in nature, that I am inclined to suppose Haüy's measures of the angles are given from calculation, assuming the cube as the nucleus, and not from measurement on the crystal. De l'Isle's description is as follows :

“ It is a blackish kind of tin ore, in small solitary crystals five or six lines in length, and at most three in breadth. In the variety in question, one of the extremities of the rectangular tetrahedral prism first presents an octahedral pyramid, the planes of which forming with the prism an angle of 155° are irregular pentagons, having one of their angles of 60° , two of 120° , one of 110° , and the most obtuse of 130° . These pentagons form with each other angles of 120° and 160° . The pyramidal form thence resulting is itself terminated by a tetrahedral summit with trapezoidal planes joining at right angles, as is observed in the isosceles triangles of the third variety : but this summit becomes octahedral by the slight truncature of its edges, from which result four linear hexagons that form by their contact at the summit of the pyramid obtuse angles of 110° . The planes of the prism, had it not been broken, would be regular hexagons, and the whole crystal would then have thirty-six facets.” *De l'Isle's Crystallographie*, Tom. III. p. 423.

Having said so much respecting the external form, a few remarks concerning the chemical analysis of tin ores cannot be misplaced in a paper like the present. On this part of the subject, I cannot do better than by quoting from a paper of C. Guyton, formerly and better known here by the name of De Morveau, whose chemical authority always carries great weight with it. In his paper entitled, *Observations on the Acid of Tin, and an Analysis of its Ores*, after giving the analyses of the brown tin ore of Schlackenwald, as published by Mr. Klaproth, which he verified himself, and found to contain, tin 75, iron 0.5, flux 0.75, and oxygen $23.75 = 100$; he proceeds to give a reason why the tin crystals

tals are so insoluble in acids, and combats the idea of Klaproth, that it arises from supersaturation by oxygen, which is dissipated by fluxing the ore with vegetable alkali.

“ I believed I had good reason,” says he, “ to doubt that the complete oxygenation, or (if the term be preferred) the supersaturation by oxygen, was the true cause of its insolubility in the muriatic acid; because I could not, at any one instant of the operation, perceive either the substance that should take it away, or any of the phenomena that would have accompanied its disengagement. That I might with the greater facility observe all the circumstances, I operated with a small platina crucible over an Argand’s lamp. Fifty-five centigrammes of brown crystals of tin were reduced to a fine powder, and mixed with six times as much pot-ash (purified by alcohol, and dried): the mixture was moistened with a few drops of water. I evaporated it first to dryness, and then to a commencement of fusion. After the first treatment, hot water poured on the mass dissolved more than half the mineral, which was then first precipitated from it by muriatic acid, and afterwards redissolved by it with the greatest facility; and the precipitate of the metallic oxyde, reproduced by adding carbonate of pot-ash, was found, as stated by Klaproth, completely soluble again by the same acid. After having myself witnessed this fact, my first doubt on the direct cause of the insolubility of this ore was rather strengthened than removed. It cannot be said that the excess of oxygen escaped during the fusion with the pot-ash; for the metal could not form a soluble combination with alkali, unless it was oxidated in the highest degree; or, more properly, in the state of an acid, so as that the solution filtered from the residue should be a true stannate, or (if the term be preferred) stannite of tin*.

“ Now, if we are obliged to admit that *all the oxygen* of the ore is again found in the alkaline solution, it cannot be the loss of *a part* of that principle that renders the metal

* The author must have written Stannite of pot-ash. D.

more soluble in the acid, for it is still found in the same state of saturation: besides, it does not exhibit any signs of the oxygenated muriatic acid gas; and in this case it is difficult to conceive why there should not rather be a disengagement of this gas at the time of digestion of the acid on the ore, as happens with the oxydes of manganese and lead.

“ To establish this point of theory on a decisive experiment, I dissolved six grammes of tin in nitrous acid, which I evaporated several times to dryness, adding each time fresh acid. I think it cannot be doubted that in this state the tin had taken all the oxygen it was capable of fixing; yet the mass of white oxyd, washed till the water that came from it did not in the least alter vegetable colours, was readily dissolved in muriatic acid. What then is the cause of the insolubility of the ore, which also is nothing but tin and oxygen, containing hardly 0.01 of extraneous matter? The cause can only be found in the state of aggregation of the latter. This assertion ought not to excite surprise, for hitherto sufficient account has not been taken of this power. If combinations are the result of affinity or elective attraction, this attraction itself is nothing but a power which may be rendered ineffectual by the sum of the forces which counteract it. These truths surely will not be denied by Mr. Klaproth, who has rendered them so palpable, by shewing us that the ruby, the sapphire, the adamantine spar, the elements of which were naturally easily soluble, resisted the ordinary means of analysis only by the state of the aggregation of their integral parts.”

De l'Isle, whose second edition was published in 1783, conjectured what Guyton here advances from experiment. His words are as follow:—“ I cannot agree with Mr. Bergman, that there is no mineralizing substance in the crystals of tin, because, in default of sulphur or arsenic, we ought at least to find *the acid principle*, by the aid of which the metallic earth of tin takes a constant and determinate crystalline form.”