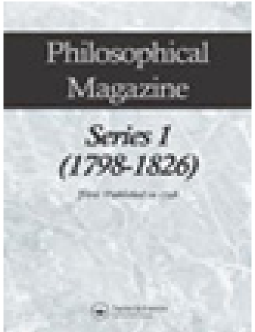

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XI. On the theory of the structure of crystals

Abbé Hauy

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of October, when the froſt becomes ſharp: nor did I ever ſee them again before the laſt week in May, or beginning of June. From their being enveloped in balls of clay, without any appearance of food, I conceive they ſleep during the winter, and remain for that term without ſuſtenance. As ſoon as I conveyed this ſpecimen to my houſe, I depoſited it, as it was, in a ſmall chip-box, in ſome cotton, waiting with great anxiety for its waking; but that not taking place at the ſeaſon they generally appear, I kept it until I found it begin to ſmell: I then ſtuffed it, and preſerved it in its torpid poſition. I am led to believe its not recovering from that ſtate, aroſe from the heat of my room during the time it was in the box, a fire having been conſtantly burning in the ſtove, and which in all probability was too great for reſpiration. I am led to this conception from my experience of the ſnow bird of that country, which always expires in a few days (after being caught, although it feeds perfectly well) if expoſed to the heat of a room with a fire or ſtove; but being nouriſhed with ſnow, and kept in a cold room or paſſage, will live to the middle of ſummer.

The animal above deſcribed belongs to Schreber's genus of Dipus, and may be characterized.

DIPUS CANADENSIS *palmis tetradactylis, plantis pentadactylis, caudâ annulatâ undique ſetoſâ, corpore longiore.*

Fig. 1. Plate VIII, repreſents the Dipus Canadenſis.

Fig. 2 ſhows it in its torpid ſtate.

XI. *On the Theory of the Structure of Cryſtals, by the Abbé* HAUY. *From Vol. XVII. of the* Annales de Chimie.

[Continued from Page 169.]

4. *Intermediate Decrements.*

THERE are certain cryſtals in which the decrements on the angles do not take place in lines parallel to the diagonals, but

but parallel to lines ſituated between the diagonals and the edges. This is the caſe when the ſubtractions are made by ranges of double, triple, &c. moleculæ. Fig. 47 (Plate IX.) exhibits an inſtance of the ſubtractions in queſtion; and it is ſeen that the moleculæ which compoſe the range repreſented by that figure, are aſſorted in ſuch a manner as if of two there were formed only one; ſo that we need only to conceive the cryſtal compoſed of parallelopipedons, having their baſes equal to the ſmall rectangles *a b c d*, *e d f g*, *h g i l*, &c. to reduce this caſe under that of the common decrements on the angles. I give the name of *intermediate decrement* to this particular kind of decreaſe, the progreſs of which will be better illuſtrated by the following example.

Syntactic Iron Ore (Fig. 48.).

De l'Iſle *Cryſtallographie*, tom. iii. b. 198 and 199. *var.* 9 and 10.

Geomet. charact. Reſpective inclination of the trapeziums *b c g o*, *n q g o*, of the riſing pyramids 135° 34′ 31″; of the edges *c g*, *g q*, 129° 31′ 16″. Angles of the trapezium *b c g o*, *b* or *c* = 103° 48′ 35″; *o* or *g* = 76° 11′ 25″.

This variety of iron ore, which for the moſt part appears under the form of two oppoſite pyramids, riſing from a common baſe, is found at Framont in les Voſges. There are ſome groupes, the ſurface of which, like the iron ore of the iſland of Elba, reflects the moſt lively priſmatic colours. The cryſtals are often ſo ſmall, that they might be taken for ſimple tetragonal laminæ; but, on cloſe inſpection, the ſmall ſpots which form the faces of the riſing pyramids may be ſeen.

Theſe cryſtals, which M. de l'Iſle claſſed among the modifications of the dodecaedron with iſoſceles triangular planes, have for nucleus a cube which performs the functions of the rhomboid, as in the ore of the iſland of Elba. The two regular hexagons, by which they are terminated, ariſe from a decrement by a ſingle range of cubic moleculæ on the angles *c*, *n*, (*fig.* 46) of the nucleus.

To

To form an idea then of the effect of the intermediary law, combined with the preceding, and which gives riſe to the lateral trapeziums, let us ſuppoſe that *c b p r* (*fig.* 49) repreſents the ſame ſquare as fig. 46, ſubdivided into ſmall ſquares, which are the external faces of as many moleculæ. If we take theſe moleculæ by pairs, ſo that they form rectangular parallelopipedons, having for baſes the oblong ſquares *b n g h*, *h g m* G, &c. and if we imagine that the ſubtractions are made by two ranges of theſe double moleculæ, the edges of the laminæ of ſuperpoſition will be ſucceſſively ranged in lines, as P G, T L, R *p*, S *p*, *k z*, *y z*, &c. and the ſum of all theſe edges will produce two faces which, departing from the angles *b*, *r*, will converge, the one towards the other, and will unite themſelves on a common ridge, ſituated above the diagonal *c p*, but inclined to that diagonal. We ſhall then have twelve faces as the complete reſult of the decrement; and calculation ſhows, that the ſix ſuperior faces, being prolonged to the point where they meet the ſix lower faces, will form with them the ſurface of a dodecaedron, compoſed of two right pyramids united at their baſes. Theſe pyramids are here incomplete by the effect of the firſt law, which gives the hexagon *a b c d r u* (*fig.* 48) and its oppoſite *.

5. *Mixed Decrements.*

In other cryſtals the decrements, either on the edges or on the angles, vary according to laws, the proportion of which cannot be expreſſed but by the fraction $\frac{2}{3}$ or $\frac{3}{4}$. It may happen, for example, that each lamina exceeds the following by two ranges parallel to the edges, and that it may at the ſame time have an altitude triple that of a ſimple molecula. Figure 54 r preſents a vertical geometrical ſection of one of the kinds of pyramids which would reſult from this decrement; the effect of which may be readily conceived by conſidering

* The erm *syntactic* denotes the combination of decrements, one of which takes place by a single range of simple moleculæ, and the other by two ranges of double moleculæ.

ſidering that AB is a horizontal line taken on the upper baſe of the nucleus, *b a z r* the ſection of the firſt lamina of ſuperpoſition, *g f e n* that of the ſecond, &c. I call *mixed decrements* thoſe which exhibit this new kind of exception from the ſimpleſt laws.

Theſe decrements, as well as the intermediary ones, rarely exiſt any where elſe, and it is particularly in certain metallic ſubſtances that I have diſcovered them. Having tried to apply the ordinary laws to a variety of theſe ſubſtances, I found ſo great errors in the value of the angles that I at firſt believed they were inconſiſtent with theory. But after I had conceived the idea of giving to this theory the extent of which I have juſt ſpoken, I arrived at reſults ſo correct, that I no longer entertained any doubt of the exiſtence of the laws on which theſe reſults depend.

Reflections on the preceding Reſults.

All the metamorphoſes to which cryſtals are ſubjected depend on thoſe laws of ſtructure juſt explained, and others of the like kind. Sometimes the decrements take place at the ſame time on all the edges; as in the dodecaedron having rhombuſes for its planes, as before mentioned; or on all the angles, as in the octaedron originating from a cube. Sometimes they take place only on certain edges or certain angles. Sometimes there is an uniformity between them, ſo that it is one ſingle law by one, two, three ranges, &c. which acts on the different edges, or the different angles; as is obſerved in the two ſolids of which I ſhall ſpeak hereafter. Sometimes the law varies from one edge to the other, or from one angle to the other; and this happens above all when the nucleus has not a ſymmetrical form; for example, when it is a parallelopipedon, the faces of which differ by their reſpective inclinations, or by the meaſure of their angles. In certain caſes the decrements on the edges concur with the decrements on the angles to produce the ſame cryſtalline form. It happens alſo ſometimes that the ſame edge,

edge, or the fame angle, is fubjected to feveral laws of decrement, that fucceed each other. In a word, there are cafes where the fecondary cryftal has faces parallel to thofe of the primitive form, and which combine with the faces produced by the decrements to modify the figure of the cryftal.

I call *fimple fecondary forms*, thofe arifing from an unique law of decrement, the effect of which entirely conceals the nucleus; and *compound fecondary forms*, thofe which arife from feveral fimultaneous laws of decrement, or from one fingle law which has not attained to its extent, fo that there remain faces parallel to thofe of the nucleus, which concur, with the faces produced by the decrement, to diverfify the afpect of the cryftal. I fhall foon make new applications of theory to the compound fecondary forms, of which fyntactic iron ore has already prefented us an example.

If amidft this diverfity of laws fometimes infulated, fometimes united by combinations more or lefs complex, the number of the ranges fubtracted were itfelf extremely variable; for example, were thefe decrements by twelve, twenty, thirty or forty ranges, or more, as might abfolutely be poffible, the multitude of the forms which might exift in each kind of mineral would be immenfe, and exceed what could be imagined. But the power which effects the fubtractions feems to have a very limited action. Thefe fubtractions for the moft part take place by one or two ranges of moleculæ. I have found none which exceeded four ranges, except in a variety of calcareous fpar, forming part of the collection of C. Gillet Laumont, the ftructure of which I have lately determined, and which depends on a decrement by fix ranges; fo that, if there exift laws which exceed the decrements by four ranges, there is reafon to believe that they rarely take place in nature. Yet, notwithftanding thefe narrow limits, by which the laws of cryftallization are circumfcribed, I have found, by confining myfelf to two of the fimpleft laws, that is to fay, thofe which produce fubtractions by one or two ranges, that calcareous fpar is fufceptible

 of

of two thouſand and forty-four different forms: a number which exceeds more than fifty times that of the forms already known*, and if we admit into the combination decrements by three and four ranges, calculation will give 8,388,604 poſſible forms in regard to the ſame ſubſtance. This number may be ſtill very much augmented in conſequence of decrements either mixed or intermediary.

The ſtriæ remarked on the ſurface of a multitude of cryſtals afford a new proof in favour of theory, as they always have directions parallel to the projecting edges of the laminæ of ſuperpoſition, which mutually go beyond each other, unleſs they ariſe from ſome particular want of regularity. Not that the inequalities reſulting from the decrements muſt be always ſenſible, if the form of the cryſtals had always that degree of finiſhing of which it is ſuſceptible; for, on account of the extreme minuteneſs of the moleculæ, the ſurface would appear of a beautiful poliſh, and the ſtriæ would elude our ſenſes. There are therefore ſecondary cryſtals wher they are not obſerved in any manner, while they are very viſible in other cryſtals of the ſame nature and form. In the latter caſe, the action of the cauſes which produce cryſtallization not having fully enjoyed all the conditions neceſſary for perfecting that ſo delicate operation of nature, there have been ſtarts and interruptions in their progreſs, ſo that, the law of continuity not having been exactly obſerved, there have remained on the ſurface of the cryſtal vacancies apparent to our eyes. In a word, it is ſeen that ſuch ſmall deviations are attended with this advantage, that they point out the direction according to which the ſtriæ are arranged in lines on the perfect forms where they eſcape our organs, and thus contribute to unfold to us the real mechaniſm of the ſtructure.

The ſmall vacuities which the edges of the laminæ of ſuperpoſition leave on the ſurface of even the moſt perfect ſe-

* In my Eſſay, p. 217 *et ſeq.* I carried the number of theſe forms only to 1019 becauſe I had not introduced as an element in my calculation a modification of the law of decrements, with the exiſtence of which I was not then acquainted.

condary

condary cryſtals by their reentering and ſalient angles, thus afford a ſatisfactory ſolution of the difficulty a little before mentioned; which is, that the fragments obtained by diviſion, the external facets of which form part of the faces of the ſecondary cryſtal, are not like thoſe drawn from the interior part. For this diverſity, which is only apparent, ariſes from the facets in queſtion being compoſed of a multitude of ſmall planes, really inclined to one another, but which, on account of their ſmallneſs, preſent the appearance of one plane; ſo that, if the diviſion could reach its utmoſt bounds, all theſe fragments would be reſolved into moleculæ, ſimilar to each other, and to thoſe ſituated towards the centre.

The fecundity of the laws on which the variations of cryſtalline forms depend, is not confined to the producing of a multitude of very different forms with the ſame moleculæ. It often happens alſo, that moleculæ of different figures arrange themſelves in ſuch a manner as to give riſe to like polyedra in different kinds of minerals. Thus the dodecaedron with rhombuſes for its planes, which we obtained by combining cubic moleculæ, exiſts in the granite with a ſtructure compoſed of ſmall tetraedra having iſoſceles triangular faces, as I ſhall prove hereafter; and I have found it in ſparry fluor, where there is alſo an aſſemblage of tetraedra, but regular; that is to ſay, the faces of which are equilateral triangles. Nay more: it is poſſible that ſimilar moleculæ may produce the ſame cryſtalline form by different laws of decrement*. In ſhort, calculation has conducted me to another reſult, which appeared to me ſtill more remarkable, which is, that, in conſequence of a ſimple law of decrement, there may exiſt a cryſtal which externally has a perfect reſemblance to the uncleus, that is to ſay, to a ſolid that does not ariſe from any law of decrement †.

* *Mem. de l'Acad.* an 1788, p. 17 & 26.

† *Ibid.* p. 23.

Various Examples of compound ſecondary Forms.

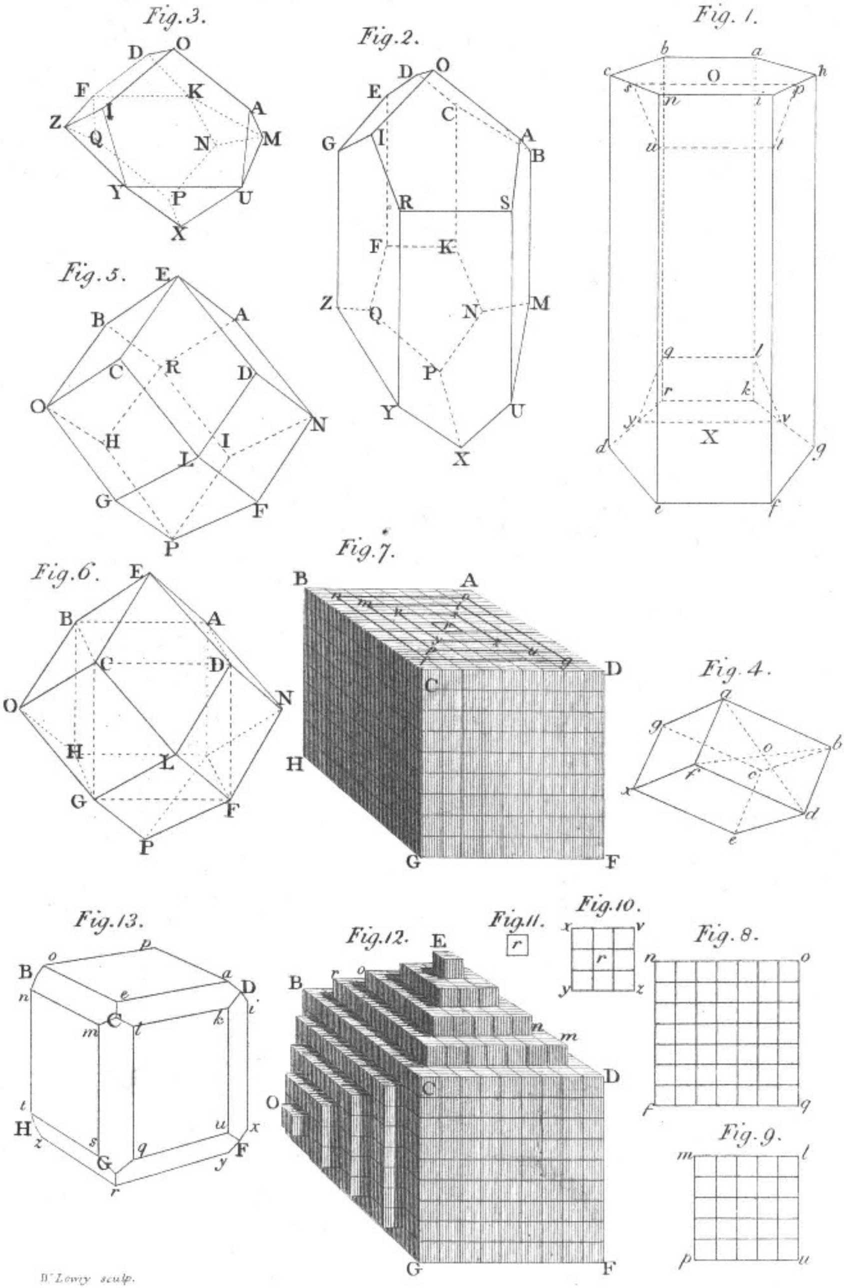
Priſmatic Calcareous Spar (*Fig.* 1. *Plate* II.)

Spath calcaire en priſme hexaèdre. Daubenton *Tab. Miner.* edit. 1792, p. 15, n° 6. De l'Iſle *Cryſtallographie*, tom. i. p. 514. var. 10.

The baſes of this priſm are produced in conſequence of a decrement by a ſingle range on the angles of the ſummits *b a f*, *g a f*, *b a g*, *d e x*, *d e c*, *c e x* (*fig.* 4.), of the primitive form. The ſix planes reſult from a decrement by two ranges on the angles *b d f*, *f x g*, *b c g*, *d f x*, *d b c*, *c g x*, oppoſite to the preceding. Let *a b d f* (*fig.* 50.) be the ſame face of the nucleus as *fig.* 4. The decreaſing edges ſituated towards the angle of the ſummit *a* will ſucceſſively correſpond with the lines *b i*, *k l*, &c. and thoſe which look towards the inferior angle *d* will have the poſitions pointed out by *mn*, *op*, &c. But in conſequence of the firſt decrement taking place by one range, we prove that the face which reſults from it is perpendicular to the axis; and calculation ſhows, in the like manner, that the ſecond decrement, which takes place by two ranges, produces planes parallel to the axis, and thus the ſecondary ſolid is a regular hexaedral priſm.

To diſplay further the ſtructure of this priſm let us remark that, in the productions of any one *a b c n i b* (*fig.* 1.) of the two baſes, we may confine ourſelves to conſider the effect of one only of the three decrements which take place around the ſolid angle *a* (*fig.* 4.), for example of that which takes place on the angle *b a f*, ſuppoſing that the laminæ applied on the two other faces, *f a g x*, *b a g c*, do not decreaſe but to aſſiſt the reſult of the principal decrement, which takes place in regard to the angle *b a f*. But here theſe auxiliarly decrements are altogether ſimilar to that the effect of which they are ſuppoſed to prolong.

The caſe will be totally different if we apply the ſame obſervation to the decrements which are effected by two ranges on the inferior angles *b d f*, *d f x*, *f x g*, &c. and which produce



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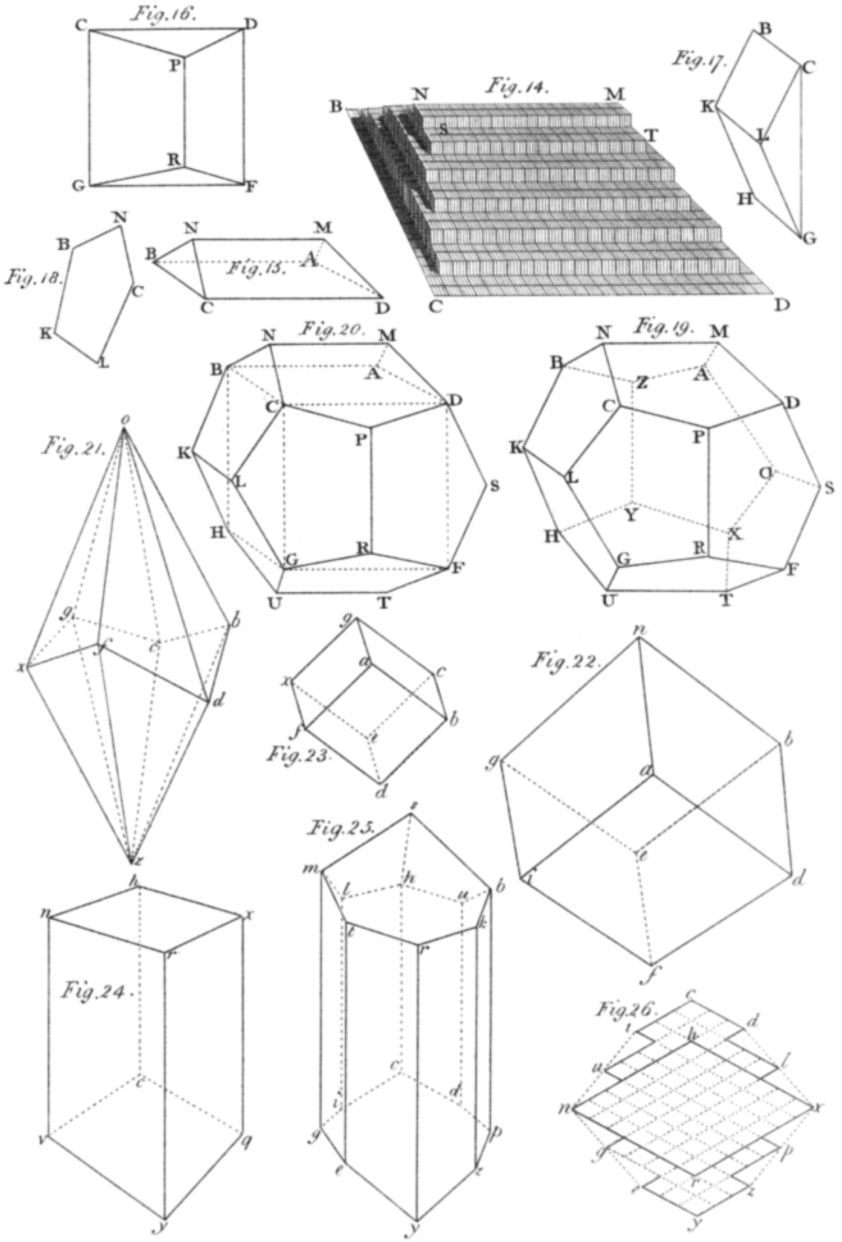

Engraved by Lowry.

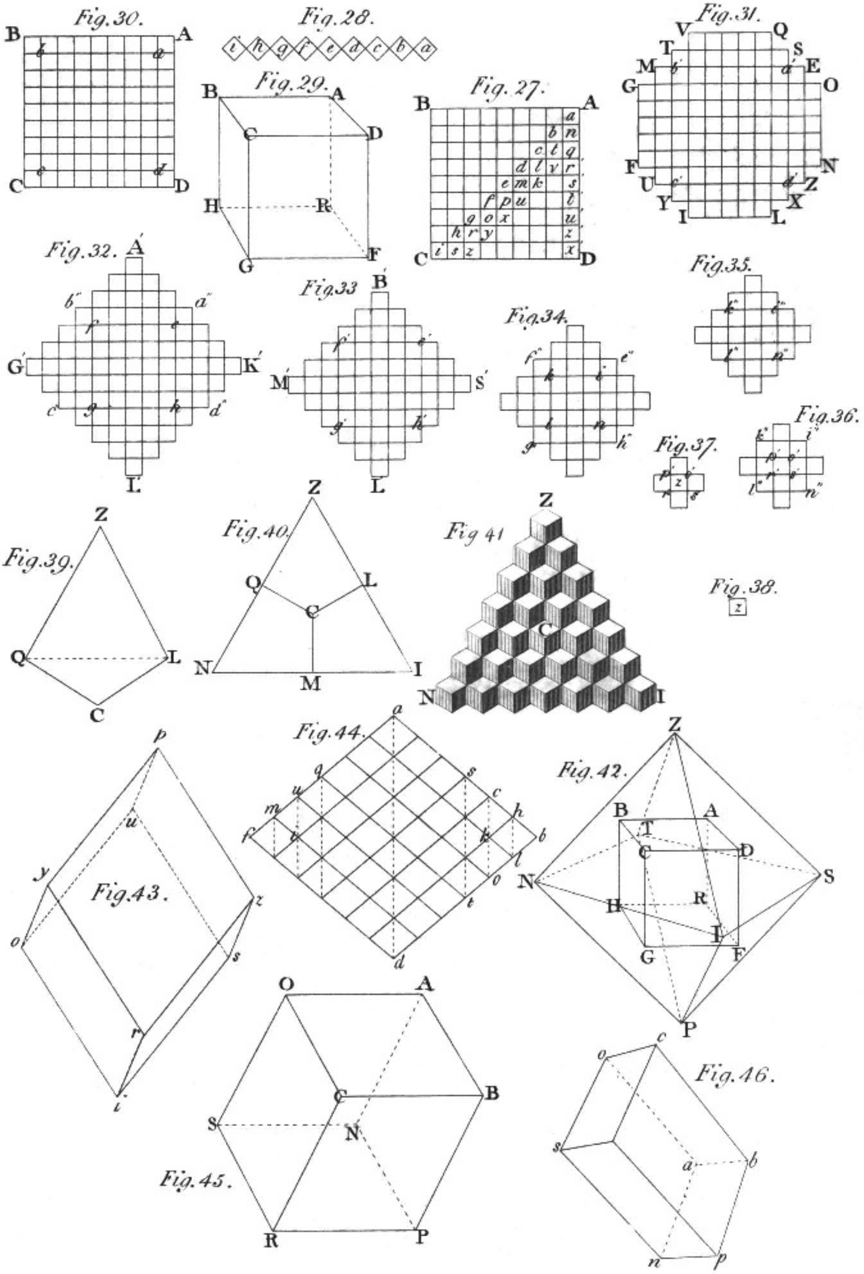
Fig. 30.
Fig. 28.
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Fig 41
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Fig. 44.
Fig. 42.
Fig. 43.
Fig. 46.
Fig. 45.

Lowry sculp.

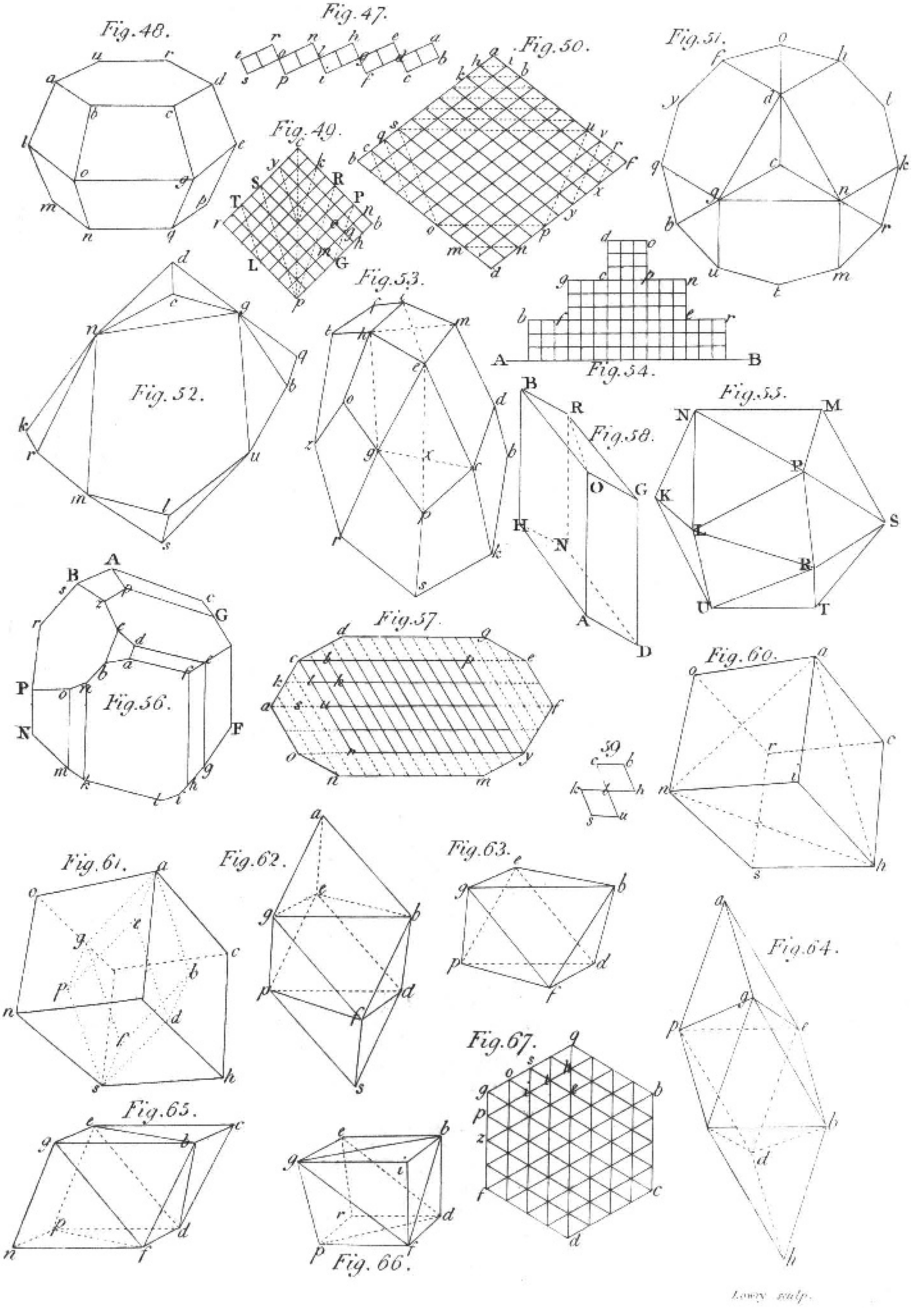
Fig. 47.
Fig. 48.
Fig. 49.
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Fig. 58.
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Fig. 60.
Fig. 61.
Fig. 62.
Fig. 63.
Fig. 64.
Fig. 65.
Fig. 66.
Fig. 67.

Lowry sculp.

duce the ſix planes of the priſm. For example, if we conſider the effect of the decrement on the angle *d f x*, it is neceſſary alſo that the laminæ applied on the faces *a f d b*, *a f x g* (*fig.* 4.), ſhould experience towards their lateral angles *a f d*, *a f x*, adjacent to the angle *d f x*, variations which ſecond the effect of the generating decrement. But here theſe variations are intermediary decrements by ranges of double moleculæ.

To conceive a better idea of theſe variations, let us reſume the face *a b d f* (*fig.* 50). The variations in queſtion will take place parallel to the lines *c e*, *r x*, *g z*, *v y*, &c. that is to ſay, by one range of double moleculæ, and in ſuch a manner that there will always be two laminæ on a level at their edges in the direction of the height. By this it is evident why the laminæ taken from the priſm by the firſt ſections are trapeziums, ſuch as *p l u s* (*fig.* 1.), in which the aſſortment of the ſmall compoſing rhombuſes will be the ſame as on the trapezium *u s o p* (*fig.* 50). We may in the like manner aſſign the reaſon of the different figures through which the laminæ, ſucceſſively detatched, before arriving at the nucleus, are obliged to paſs. But this detail would lead us too far. In a word, I muſt here repeat, that every thing is included in the effect of the principal decrements: that is to ſay, in the preſent caſe, of thoſe which take place on the ſuperior and inferior angles, or parallel to the horizontal diagonals; and after the firſt lamina of ſuperpoſition, the figure of the cryſtal is given according to this ſingle condition, that the initial faces be prolonged ſo as to interſect each other.

The priſm is ſuſceptible of varying in the length of its axis compared with its thickneſs, which depends on the different epochs at which the decrements commence, or are ſuppoſed, to commence. For example: if we ſuppoſe that the decrement, which takes place towards the inferior angle, acts alone at firſt on a certain number of laminæ, the axis of the cryſtal will be ſo much the longer as the commencement of the decrement on the ſuperior angles ſhall have been retarded. This difference of epochs becomes ſenſible by inſpecting the dodecaedron, *fig.* 2, which is one of the reſults of the mechanical diviſion of the priſm. It is there ſeen that the pentagonal laminæ of the ſummits, ſuch as A O I R S, decreaſe only by their edge R S, which correſponds to the inferior angle *b d f* (*fig.* 4.), while, by their upper parts, they continue to envelop the cryſtal without experiencing any decrement towards that ſide; ſo that it is only on the laminæ moſt diſtant from the axis, as that correſponding to *p s u l*, that the two decrements take place at the ſame time.

The reſult which we have explained is general; that is to ſay, that, whatever may be the angles of the primitive rhomboid, the ſecondary ſolid will always be a regular hexaedral priſm.

Amphitrigonous Iron Ore.

(*Fig.* 51 repreſents this cryſtal in a horizontal projection, and *fig.* 52 in perſpective.)

Mine de fer a 24 faces. Daubenton *Tab. Miner.* edit. 1792, p. 30, n° 2. De l'Iſle *Cryſtallographie*, tom. iii. p. 193 et ſuiv. var. 5, 6, 7.

Geomet. charact. Reſpective inclination of the triangles *g c n*, *g c d*, &c. from the ſame ſummit 146° 26′ 33″; of the lateral triangles *b g u*, *b g q*, to the adjacent pentagons, ſuch as *g u t m n*, 154° 45′ 39″.

This form is that under which the iron ore of the iſland of Elba moſt commonly appears. It reſults from a decrement by two ranges on the angles *c*, *n* (*fig* 46.), to the ſummits of a cubic nucleus which produces the iſoſceles triangles *g c n*, *g c d n c d* (*fig.* 51 and 52), and of a ſecond decrement by three ranges on the lateral angles *c b p*, *c r p*, *c r s*, &c. which produce the triangles *m n r*, *r n k*, *u g b*, *q g b*, &c. Theſe two decrements ſtop at a certain term, ſo that there remain faces parallel to thoſe of the nucleus, viz. the pentagons *g u t m n*, *b d n k l*, &c. (*fig.* 51.)

The

The firſt decrement is the ſame as that which produces the rhomboidal iron ore already mentioned. The ſecond hsv this property, that, if its effect were complete, it would give a dodecaedron of iſoſceles triangles, or compoſed of two right pyramids united at their baſes. In the caſe of any other decrement by two, four or more ranges, the faces of the dodecaedron would be ſcalene triangles.

The triangles of the ſummits are frequently furrowed by ſtriæ, parallel to the baſes *g n*, *d n*, *g d*, of theſe triangles, and which point out the direction of the decrement.

Analogical Calcareous Spar (*Fig* 53).

De l'Iſle *Cryſtallographie*, tom. i. p. 543, pl. 4, fig. 36.

Geomet. charact. Inclination of any one, *i m e b*, of the trapezoids of the ſummits to the correſponding vertical trapezoid *e c p g* 116° 33′ 54″; angles of the ſame trapezoid, *i* = 114° 18′ 56″; *e* = 75° 31′ 20″; *m* or *b* = 85° 4′ 52″. Angles of the trapezoid *e b o g*, *e* = 90°; *o* = 127° 25′ 53″; *g* = 67° 47′ 44″; *b* = 74° 46′ 23″; of the trapezoid *c e g p*, *e* = 60°; *p* = 98° 12′ 46″; *c* or *g* = 100° 53′ 37″.

Geomet. propert. 1. In each vertical trapezoid the triangle *c e g* is equilateral. 2. The height *e x* of this triangle is double the height *p x* of the oppoſite triangle *c p g*. 3. In the trapezoid *e b o g* and the others ſimilarly ſituated the angle *b e g* is a right angle. 4. If the diagonal *g b* be drawn, the triangle *b e g* will be ſimilar to any one *a o f* (*fig* 4.) of thoſe which would be produced by drawing, in the primitive rhombus, the two diagonals *b f*, *a d*. 5. If in the trapezoid *e m i b*, or any other ſituated at the ſummits, the diagonals *e i*, *m b*, be drawn, the height *e l* of the inferior triangle *m e b* will be double the height *i l* of the ſuperior triangle *m i b*. 6. The triangle *m i b* is ſimilar to half of the rhombus of very obtuſe ſpar, divided by the horizontal diagonal; and the triangle *m e b* is ſimilar to half of the rhombus of the acute ſpar, divided in the ſame manner.

The

The numerous analogies by which this variety is connected with different cryſtalline forms, whether we conſider certain angles formed by planes, as the angle *b e g* of 90°, the angle *c e g* of 60°, or certain triangles obtained by drawing the diagonals of the trapezoids, have induced me to give it the name of *analogical ſpar*. It is derived from three other varieties mentioned before, viz. very obtuſe ſpar by the trapezoids *e m i b*, *f i b t*, &c.; metaſtatic ſpar by the trapezoids *e m d c*, *e b o g*, *o b t z*, &c. and the priſmatic ſpar by the trapezoids *b d c k*, *c e g p*, &c. which are conſequently parallel to the axis.

It often happens that the trapezoids *i m e b*, *f i b t*, &c. are ſeparated, by an intermediary ridge, from the vertical trapezoids *c e g p*, *g o z r*, &c. In that caſe the trapezoids *c d m e*, *g e b o*, &c. are changed into pentagons. I have here ſuppoſed the cryſtal brought back to the moſt ſymmetric figure, that is to ſay, having its ſurface compoſed only of quadrilaterals, as ſometimes happens. This variety is found in Derbyſhire.

Icoſaedral Sulfure of Iron (*Fig.* 55).

Pyrite ferrugineuſe polyèdre à vingt faces triangularies. Daubenton *Tab. Miner.* edit. 1792, p. 30. De l'Iſle *Cryſtallographie*, tom. iii. p. 233, var. 22.

Geomet. charact. Reſpective inclinations of the iſoſceles triangles P L R, P S R, 126° 52′ 11″; of any one P N L of the equilateral triangles, to each adjacent iſoſceles triangle P L R or L N K 140° 46′ 17″. Angles of the iſoſceles triangle P L R, L = 48° 11 20″; P or R = 65° 54′ 20″:

This variety reſults from a combination of the law which produces the octaedron originating from a cube (*fig.* 42.), with that which takes place for the dodecaedron with pentagonal planes (*fig.* 19 *and* 20). The firſt law gives birth to the eight equilateral triangles which correſpond with the ſolid angles of the nucleus, and the ſecond to twelve iſoſceles triangles,

triangles, ſituated, two and two, above the ſix faces of the ſame nucleus. If we had a dodecaedron ſimilar to that of *fig.* 20, and wiſhed to convert it geometrically into an icoſaedron, ſuch as that in queſtion, it would be ſufficient to make the planes of eight ſections paſs through it in the following manner, viz. one through the three angles P, N, L, (*fig.* 19.), another through the angles P, M, S, a third through the angles L, R, U, &c. A compariſon of the figures 19 and 55 will ſhow, by the correſpondence of the letters, the relation between the two polyedra; but this is an operation merely technical, to which nature could not deſcend. I ſhall obſerve beſides, that the nucleus of the icoſaedron, to which we ſhould arrive, would be much ſmaller than that of the dodecaedron, ſince the ſolid angles of the latter nucleus would be confounded with the angles D, C, G, &c. (*fig.* 20.) of the dodecaedron; whereas the other nucleus would have its ſolid angles ſituated in the middle of the equilateral triangles M P S, N P L, U R L, &c. (*fig.* 55).

The icoſaedron of the ſulphure of iron has been confounded with the regular icoſaedron of geometry, which differs from it very ſenſibly, ſince all its triangles are equilateral. It is demonſtrated by theory, that the exiſtence of the latter icoſaedron is as impoſſible in mineralogy as that of the dodecaedron; ſo that among the five regular polyedra of geometry, viz. the cube, the tetraedon, the octaedron, the dodecaedron, and the icoſaedron, the three former only can exiſt there in conſequence of the laws of cryſtallization. It is not uncommon therefore to find them among cryſtals of various kinds of minerals.

The icoſaedron of the ſulphure of iron is much leſs common than the dodecaedron. It is found in ſolitary cryſtals. I have one which is complete, and about half an inch in thickneſs.

Polynomous

Polynomous Petunzé (Fig. 56) *.

Spath étincelant ou feld-ſpath en priſme à dix pans avec des ſommets à deux faces et quatre facettes. Daubenton *Tab. Miner.* edit. 1792, p. 4, var. 2.

Geomet. charact. Reſpective inclination of the narrow planes *o n k m*, *c f b g*, to the adjacent planes on each ſide 150°; of the planes *c t F g*, P *o m* N to thoſe contiguous to them by the edges *t* F, P N 120°; of the heptagon *p* G *c l d e z* to the enneagon B *z e b n o* P *r s*, 99° 41′ 8″; of the trapezium *d a f c* both to the plane *n b a f b i l k* and to the heptagon *p* G *t c d e z*, 135°; of the facet *d e a b* or A B *z p* to the ſame heptagon, 124° 15′ 15″.

I have not yet obſerved the petunzé naturally cryſtallized under its primitive form. This form, ſuch as it is given by the mechanical diviſion of ſecondary cryſtals, is that of an oblique priſm of four planes (*fig.* 58), two of which, ſuch as G O A D, R B H N, are perpendicular to the baſes A D N H, O G R B. The other two, viz. B O A H, R G D N, make, with the former, angles of 120° at the ridges O A, R N, and angles of 60° towards the oppoſite ridges B H, G D. Theſe planes are inclined to the baſes at the place of the ridges G O, B R, 111° 29′ 43″, and at the oppoſite ridges 68° 30′ 17″.

This form is at the ſame time that of the moleculæ. Theory ſhows that the two parellelograms G O A D, O G R B, as well as their parallels, are equal in extent; and that the parallelogram B O A H, or its oppoſite, R G D N, is double each of the preceding; which may ſerve to explain the roughneſs of the ſections made in the direction B O A H, when compared with thoſe obtained in the directions of the

* I have adopted the name petunzé, which is that given to this ſubſtance in China, where it is employed in making porcelain. The word spar (*spath*) has become so vague, by the application of it to substances very different in their nature, that it is much to be wished that it were banished from the nomenclature of minerals.

ſmall

ſmall parallelograms, and which are always extremely ſmooth and brilliant. Moreover, if the diagonal O R be drawn, it will be found perpendicular to O A and R N; or, what amounts to the ſame, will be ſituated horizontally, by ſuppoſing that the ridges O A, B H, &c. have a vertical poſition. We ſhall ſoon have occaſion to make uſe of this obſervation.

The polynomous petunzé preſents the moſt complicated variety which I have obſerved among cryſtals of this kind. To form an idea of its ſtructure, let us ſuppoſe that *b p y r* (*fig.* 57) repreſents a ſection of the nucleus A R (*fig.* 58) made by a plane perpendicular to the parallelograms G O A D, B O A H, and ſubdivided into a multitude of ſmall parallelograms, which are the analogous ſections of ſo many moleculæ. Here the ſide *y r* (*fig.* 57) which is the ſame ſection of the cutting plane as G O A D, is greater than it ought to be in regard to the ſide *c r* (*fig:* 57), which is the ſame ſection as B O A H (*fig.* 58): but theſe dimenſions are ſuited to thoſe of the ſecondary cryſtal, and here occaſion no difficulty, becauſe we may ſuppoſe that the primitive form has been extended more in one direction than in another; for this form, as I have already remarked, is only a convenient *datum* for the explanation of the ſtructure, and the cryſtal conſiſts merely in an aſſemblage of ſimilar moleculæ; ſo that it is the dimenſions of theſe moleculæ which remain invariable.

This being premiſed, we ſhall find, by comparing the figures 56 and 57; 1ſt, that the plane *f a b n k l i b* (*fig.* 56) and its oppoſite, which correſpond to *m n*, *d g*, (*fig.* 57), are parallel to two of the planes of the nucleus, viz. G O A D, B R N H (*fig.* 58), and conſequently do not reſult from any law of decrement; 2d, that the plane P *o m* N, and its oppoſite (*fig.* 56), which correſpond to *a o*, *e g* (*fig.* 57), are alſo parallel to two of the planes of the nucleus, viz. B O A H, R G D N (*fig.* 58); 3d, that the plane *o n k m* and its oppoſite (*fig.* 56), which correſpond to *o n*, *e g*, (*fig.

(*fig.* 57) reſult from a decrement by two ranges parallel to the ridges A O, N R (*fig.* 58); 4th, that the plane *c f g h* and its oppoſite (*fig.* 56), which correſpond to *my*, *dv* (*fig.* 57), reſult from a decrement by four ranges parallel to the ridges G D B H (*fig.* 58); 5th, that the plane *c t* F *g* and its oppoſite (*fig.* 56), which correſpond to *fy*, *c a* (*fig.* 57), reſult from a decrement by two ranges parallel to the ſame ridges G D, B H (*fig.* 58), which decrement takes place on the other ſide of theſe ridges. It may be ſeen by what has been already ſaid, that decrements different in their meaſure give riſe to planes ſimilarly ſituated, ſuch as *o n k m* and *c f g h* (*fig.* 56), which is a conſequence of the particular figure of the moleculæ.

With regard to the faces of the ſummit, the heptagon *p* G *t c d e z* (*fig.* 56) is ſituated parallel to the baſe B R G O (*fig.* 58). The enneagon B *s r* P *o n b e z* (*fig.* 56) is produced in conſequence of a decrement by one range on the angle O B R (*fig.* 58), or parallel to the diagonal O R; which decrement does not attain to its full extent, and leaves ſubſiſting the neighbouring heptagon parallel to the baſe B R G O. It may be readily conceived, after what has been ſaid on the poſition of the diagonal O R, why the line *e z* (*fig.* 56), which ſeparates the two large faces of the ſummit, is ſituated horizontally, ſuppoſing that the planes have a vertical poſition.

The trapeziums *d a f c*, A *p* G C, reſult from a decrement by one range on the ridges G O, B R, (*fig.* 58). The facet *d e b a* (*fig.* 56) ariſes from a decrement by two ranges, parallel to the ridge B O (*fig.* 58). With regard to the other facet A B *z p*, which has the ſame poſition as the preceding, in regard to the oppoſite part of the cryſtal, it reſults from an intermediary law by a range of double moleculæ on the angle O B R (*fig.* 58). The rhombuſes *b c l h*, *k l ſ u* (*fig.* 59), repreſent the horizontal ſections of two of theſe double moleculæ, taken in the ſame range, and whoſe relation to the reſt of the aſſortment will became ſenſible by comparing

comparing the rhombuses in question with those marked by the same letters (*fig.* 57).

The crystals of this variety are subject to a change of dimensions, which is, that the faces *p* G *t c d e z*, *f a b n k l i b*, and their opposites, which are at right angles to each other, are stretched out, in the direction of their breadth, in such a manner that they exhibit the appearance of a quadrilateral rectangular prism, the summits of which would be formed by the faces situated towards the ridges P N, F *t*.

This variety is found in opake crystals, and of a whitish, yellowish, and sometimes reddish colour, in the granites of Auvergne, and of different countries. There are some of them in groupes and some single, but the latter are uncommon.

[*To be concluded in the next Number.*]

XII. *Description of the Apparatus employed by* LAVOISIER *to produce Water from its component Parts, Oxygen and Hydrogen.*

THE discovery made by Mr. Cavendish of the composition of water having effected a complete revolution in the theory of chemistry, it will no doubt gratify many of our readers to see some account of the principal apparatuses which have been contrived to exhibit this phenomenon.

Fig. 1, Plate X. is that used by Mr. Lavoisier. A is a balloon holding about 30 points, having a large opening, to which is cemented the plate of copper B pierced with four holes, in which four tubes terminate. The first tube H *h* is intended to be adapted to an air-pump, by which the balloon may be exhausted of its air. The second tube *gg* communicates by its extremity M M with a reservoir of oxygen gas, from which the balloon is to be filled. The third tube *d* D *d* communicates by its extremity *d* N N with a reservoir of hydrogen gas. The extremity *d* of this tube terminates in a capillary opening, through which the hydrogen gas contained in