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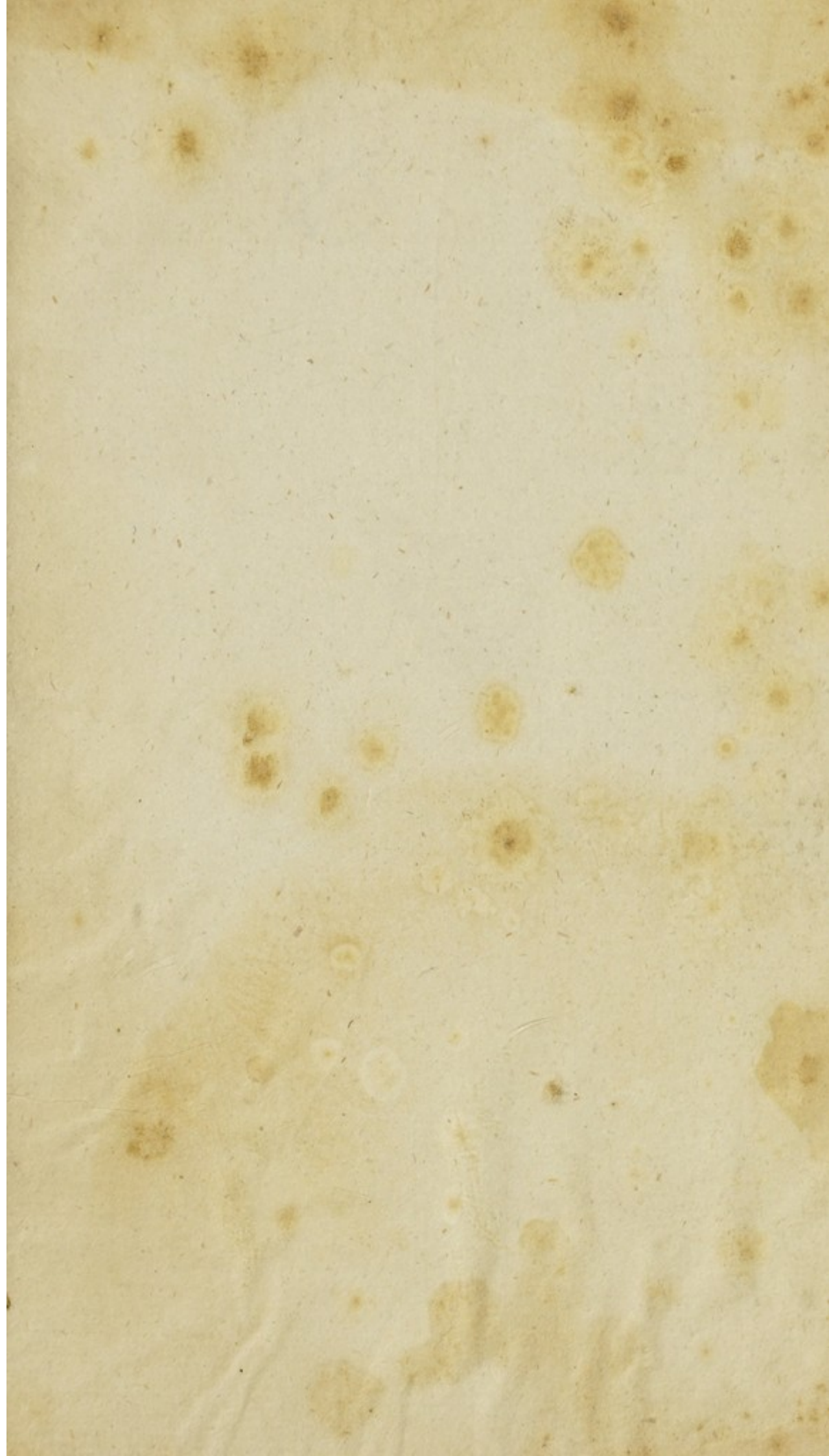


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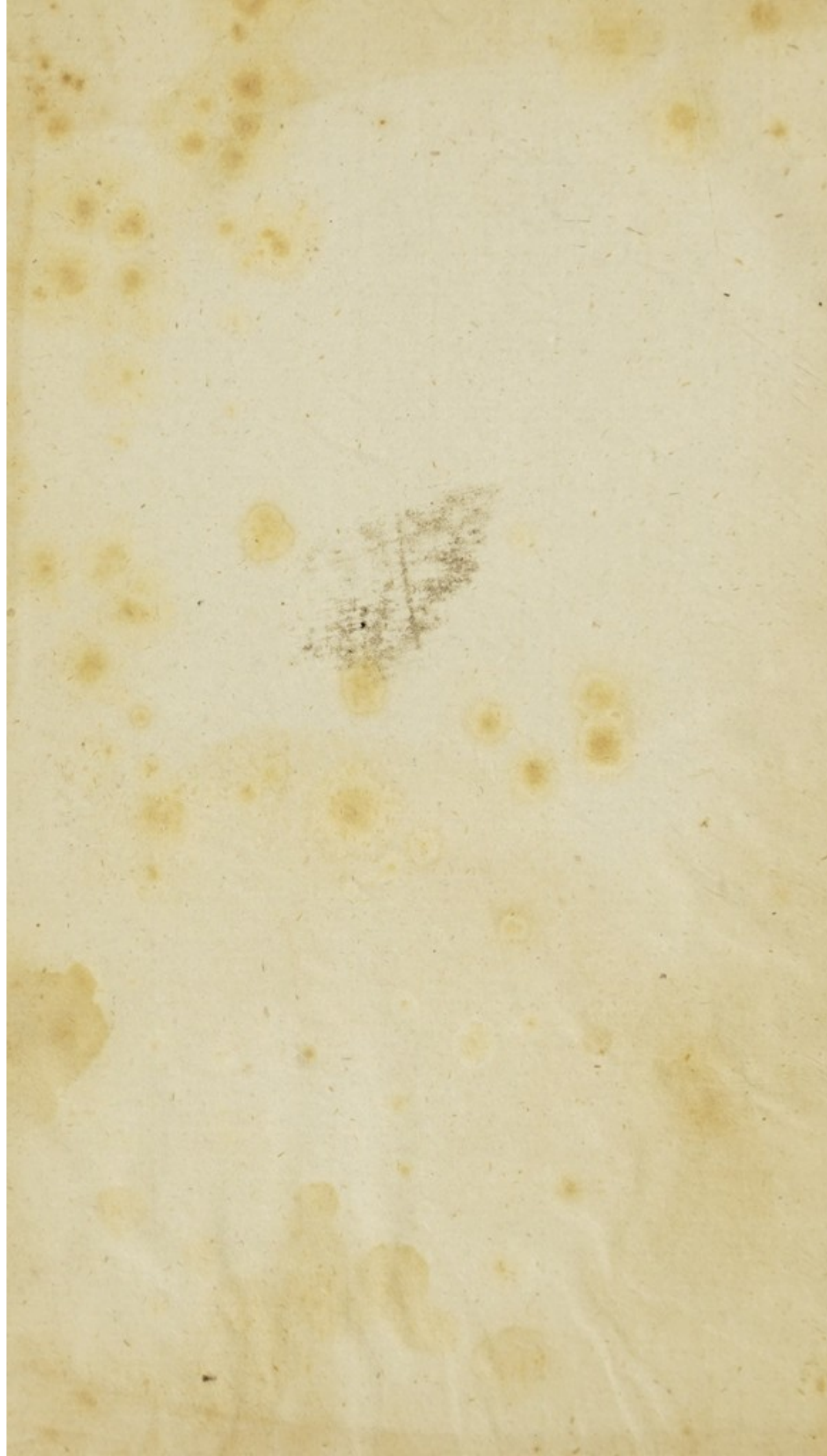




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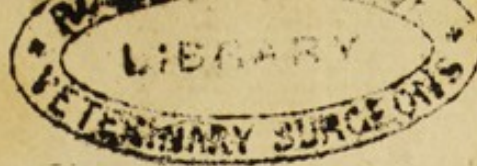








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# E L E M E N T S

O F

# C H E M I S T R Y.

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SCIENCES, MEDICINE, AGRICULTURE, IN-  
SCRIPTIONS AND BELLES LETTRES.

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TRANSLATED FROM THE FRENCH.

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THE SECOND EDITION.

IN THREE VOLUMES.

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V O L. II.

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L O N D O N:

PRINTED FOR G. G. AND J. ROBINSON,  
PATERNOSTER-ROW.

M.DCC.XCV.





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# C O N T E N T S

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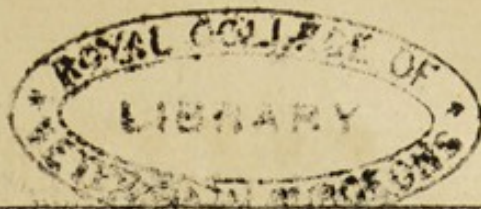
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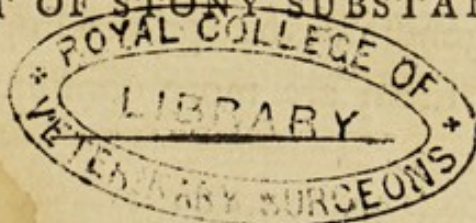


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E L E M E N T S  
O F  
C H E M I S T R Y.

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PART THE SECOND.  
CONCERNING LITHOLOGY; OR AN AC-  
COUNT OF STONY SUBSTANCES.



I N T R O D U C T I O N.

**T**HE object of Lithology consists in the study of stones and earths.

It is generally agreed to call those substances by the name of Earth or Stone, which are dry, brittle, inodorous, insipid, scarcely or not at all soluble in water, and of a specific gravity not exceeding 4,5.



There is no one who has seriously attended to the study of lithology, without being at the same time aware of the necessity of establishing divisions to facilitate the knowledge of stones, and to remove the numberless difficulties which would otherwise oppose the acquisition of that knowledge.

It is an obvious difference between living creatures and the subjects of the mineral kingdom, that these last are continually modified by external causes, such as air, water, fire, &c. while the former, being animated and governed by an internal force, possess characters of a more definite and unchangeable nature. The forms of these depend upon their organization; and, in general, the proceedings of nature respecting them are more constant, and better ascertained.

The earthy element appears to be passive of itself: it is obedient only to the laws of inanimate bodies; and we may refer all the phenomena of formation or decomposition, which a stone is susceptible of, to the mere law of affinities. This, no doubt, is the cause of that variety of forms, and that mixture of principles, which scarcely permit the naturalist to establish his system upon fixed bases, or to found it upon constant and invariable characters.



If we take a view of the proceedings of all the naturalists who have hitherto written, we may easily reduce them to three classes.

1. The first class, carried by the imagination alone to that epocha when this globe issued from the hands of the Creator, have followed the actions of the various destructive agents which alter or overturn its surface. In this way they have shewn us the various rocks successively deposited or placed upon the primitive globe; and, by surveying the great phenomena which have happened upon our planet, they have acquired ideas more or less accurate respecting the vast works of decomposition and formation.

2. Others have busied themselves in enquiring, by analysis, what are the earths or primitive matters out of which all the stones we are acquainted with are composed. This class of philosophers have supplied us with the most valuable acquisitions respecting the nature, the uses, and the decompositions of these substances: but the results of analysis, though necessary in acquiring accurate notions of each stone, are not of themselves sufficient to form the basis of a method of classing; because these characters are too difficult to be acquired, and at most can be used only as supplementary in the establishment of such other methods as may be employed.



3. Almost all the systems of classification hitherto adopted, are founded upon the external characters of earthy substances.

Some naturalists have sought, in the variety of forms exhibited by the productions of the mineral kingdom, such principles of division as to them appeared sufficient. But not to mention that the same form frequently obtains in very different stones, this character is rarely found, and we are ignorant of the crystallization of most of the known earths: the crystallization cannot therefore be considered but as an accessory or secondary circumstance.

Other naturalists have established their divisions upon certain properties easy to be ascertained, such as that of effervescing with acids, giving fire with the steel, &c. But these characters do not appear to be sufficiently strict, nor sufficiently exclusive: for nothing is more common than to find a mixture of the fragments of primitive rocks with those of calcareous stones. Our province exhibits examples of this every step we take; and these mixtures, hardened by time, possess both the before-mentioned characters. There are also stones which, without changing their nature, give fire with the steel, or effervesce with acids, accordingly as they are more or less divided. Such is the lapis lazuli,



lazuli, which effervesces when pulverized, but strikes fire when in the mass; the slate likewise effervesces when in powder, but not in the mass. The classification, therefore, which is founded on these characters, is not rigorous, and they may at the most be made use of in conjunction with others.

M. D'Aubenton is the naturalist who appears to me to have distributed mineral substances with the greatest order of any who has hitherto undertaken that task: every thing which he says on this subject shews the experienced eye of the observer; and he has drawn from the external characters of bodies all the characters possible to be had from that source. But he could not avoid the defects which necessarily accompany the principles on which he has founded his system.

Deeply impressed with a sense of the insufficiency of these methods, as well as of the slight opportunities I have possessed of improving them, my endeavours have been exerted in collecting together all the characters which are capable of affording any useful indications. In this pursuit, I have joined the characters of the naturalist to those of the chemist; and though the method which I have adopted be very far from that degree of perfection which might be



desired, I nevertheless present it to the public with confidence. It differs but little from that followed by Messrs. Bergmann and Kirwan; a circumstance which at least affords a prejudice in its favour. The peculiar advantages which, in my opinion, it appears to possess, are—1. The lithologic productions are distributed equally, and into three classes. 2. All the analogous productions are brought together, and arranged as it were in a natural order. In a word, this system has fixed my own ideas in the most precise manner; and this has more particularly induced me to propose it to the public\*.

The

\* I consider what is here published respecting Lithology as a simple and short sketch of the principles which I explain in my Lectures. It would be judging me with too much severity, if the reader were to suppose that my present design is to exhibit a complete performance.

A more intimate acquaintance with this subject may be obtained by the perusal of the following works:

1. Essai d'un Art de Fusion, à l'Aide de l'Air Vital, par Erhmann.—Mémoires de M. Lavoisier sur le même Sujet.—Mémoires de M. D'Arcet, sur l'Action d'un Feu égal, violent, et continu, sur un grand Nombre de Terres, Pierres, &c.
2. The Works of Margraff and Pott, more especially the Lithogegnesia of the latter.
3. Les Pesanteurs Spécifiques des Corps, par M. Briffon.
4. Elements of Mineralogy, by Mr. Kirwan.
5. Le Manuel du Minéralogiste de Bergmann, enrichi de Notes par M. l'Abbé Mongez.



The various earths beneath our feet are, in general, combinations; and chemists, by decomposing these substances, have succeeded in obtaining, in the last analysis, principles which may be considered as earthy elements, until subsequent acquisitions shall either confirm or destroy our ideas on this subject.

The earthy elements most extensively distributed are five in number; namely, Lime, Magnesia, Barytes, Alumine, and Silex.

We shall not treat of the other primitive earths announced by Mr. Klaproth, in the adamantine spar, and in the jargon of Ceylon, because they are yet too slightly known, and too scarce, to have any influence upon our present division.

6. *La Minéralogie* de M. Sage.

7. *Les Ouvrages sur la Cryсталlographie* de M. de Romé de Lisle, de M. l'Abbé Haüy, &c.

8. *Le Tableau Méthodique des Minéraux*, par M. D'Aubenton.

9. *La Minéralogie* de M. le Comte de Buffon; in which that celebrated writer has collected a great number of valuable facts, whose merit is independent of all theory.

10. *The Mineralogical Works* of Messrs. Jars, Deitrich, De Born, Ferber, Trebra, Pallas, Gmelin, Linné, Dolomieu, De Saussure, De la Peyrouse, &c.

11. *The excellent Analyses of Stones*, published from time to time by Pott, Margraff, Bayen, Bergmann, Gerard, Scheele, Achard, Mongez, &c.



Nature appears to have formed all the mixtures and combinations which constitute stones, out of the primitive earths here spoken of.

If we direct our attention to the nature of these mixtures and combinations, we shall distinguish three habitudes, or modes, which establish three grand divisions. We shall immediately perceive that these earths are, in some instances, combined with acids, which form saline stones; that in other instances they are mixed with each other, and form stones properly so called; and that in other instances, again, these stones, so formed by the mixture of primitive earths, are united together, or fixed in a gluten or cement, which forms rocks, pebbles, or compound stones.

We shall therefore distinguish three classes in Lithology: the first will comprehend saline stones; the second stones, properly so called, or earthy mixtures; and the third rocks, or stony admixtures.

We consider it as indispensably necessary to explain the nature of the primitive earths, before we can proceed to treat of their combinations.



## I. Lime.

This earth has been found totally disengaged from all combination, near Bath.—See Falconer on the Bath Waters, vol. i. page 156 and 157. But as this is perhaps the only observation of the kind which we possess, it is indispensably necessary to shew the process by which lime may be obtained in a state of the greatest purity.

For this purpose chalk is to be washed in boiling distilled water, then dissolved in distilled acetic acid, and precipitated by the carbonate of ammoniac, or mild volatile alkali. The precipitate, being washed and calcined, is pure lime.

This earth possesses the following characters:

1. It is soluble in six hundred and eighty times its weight of water, at the temperature of sixty degrees of Fahrenheit. Kirwan.

2. It has a penetrating, acrid, and burning taste.

3. Its specific gravity is about 2,3 according to Kirwan, and 2,720 according to Bergmann.

4. It seizes water with great avidity; at the same time that it falls into powder, increases in bulk, and emits heat.

5. Acids



5. Acids dissolve it without effervescence, but with the production of heat.

6. The borate of soda, or borax, the oxides of lead, and the phosphates of urine, dissolve it by the blow-pipe without effervescence.

It appears to be infusible alone, as it has resisted the heat of flame urged by a stream of vital air.—See the Memoir of Mr. Lavoisier.

When it is mixed with acids, it forms a fusible combination; and it hastens the fusion of aluminous, siliceous, and magnesian earths, according to the experiments of Messrs. Darcet and Bergmann.

## II. Barytes, or Ponderous Earth.

We are indebted to the celebrated chemists Gahn, Scheele, and Bergmann for our knowledge of this earth.

It has not yet been found exempted from all combination; but in order to obtain it in a suitable degree of purity, the following process may be used:

The sulphate of barytes, or ponderous spar, which is the most usual combination met with on the earth, is to be pulverized, and calcined in a crucible, with an eighth part of powder of charcoal: the crucible must be kept ignited during an hour; after which the calcined matter is to be  
thrown



thrown into water: it communicates a yellow colour to this fluid, at the same time that a strong smell of hepatic gas is emitted; the water is then to be filtered, and muriatic acid poured in: a considerable precipitate falls down, which must be separated from the fluid by filtration. The water which passes through the filter holds the muriate of barytes, or marine salt of ponderous earth, in solution. The carbonate of pot-ash, or mild vegetable alkali, in solution, being then added, the ponderous earth falls down, in combination with the carbonic acid; and this last principle may be driven off by calcination.

1. Pure barytes is of a pulverulent form, and extremely white.

2. It is soluble in about nine hundred times its weight of distilled water, at the temperature of sixty degrees, according to Kirwan.

3. The Prussiate of pot-ash, or Prussian alkali, precipitates it from its combination with the nitric and muriatic acids. This habitude distinguishes it from other earths.—See Kirwan.

4. It precipitates alkalis from their combinations with acids.

5. Barytes exposed, by Mr. Lavoisier, to flame fed with oxygenous gas, was fused in a few seconds:

*false  
green.*



seconds: it extended itself upon the surface of the coal; after which it began to burn and detonate until the whole was nearly dissipated. This kind of inflammation is a character common to metallic substances; but when the barytes is pure, it is perfectly infusible.—See Lavoisier.

Ponderous earth urged by the blow-pipe makes little effervescence with soda, but is perceptibly diminished: it dissolves in the borate of soda with effervescence, and still more with the phosphates of urine.—See the abbé Mongez' *Manuel du Minéralogiste*.

6. Its specific gravity exceeds 4,000, according to Kirwan.

### III. Magnesia, or Magnesian Earth.

This earth has been nowhere found disengaged from all foreign substances; but in order to obtain it in the utmost possible state of purity, the crystals of the sulphate of magnesia, or Epsom salt, are to be dissolved in distilled water, and decomposed by the carbonate of alkali. The precipitate must then be calcined, to disengage the carbonic acid.

1. Pure magnesia is very white, very friable, and, as it were, spongy.

2. Its specific gravity is about 2,33 according to Kirwan.

3. It is not perceptibly soluble in water when pure;



pure; but when it is combined with the carbonic acid, it is soluble; and cold water has a stronger action on it than hot, according to the experiments of Mr. Butini.

4. It has no perceptible action on the tongue.

5. It slightly converts the tincture of turnsole to a green.

6. Mr. Darcet has observed, that a strong heat agglutinates it more or less: but Messrs. De Morveau, Butini, and Kirwan, found that it was not fusible; and the experiments of Mr. Lavoisier have proved that it is as infusible as barytes and lime.

The borate of soda, and the phosphates of urine, dissolve it with effervescence.—See the abbé Mongez.

#### IV. *Alumine, or Pure Clay.*

This earth is not more exempt from mixture and combination than the foregoing; and in order to obtain it in a state of purity, the sulphate of alumine is dissolved in water, and decomposed by effervescent alkalis.

1. Pure clay seizes water with avidity, and may then be kneaded. It adheres strongly to the tongue.

2. Its specific gravity does not exceed 2,000 according to Kirwan.

3. When exposed to heat, it dries, contracts, shrinks,



shrinks, and becomes full of clefts. A considerable degree of heat renders it so hard that it gives fire with the steel.

When it has been well baked, it is no longer capable of uniting with water; but requires to be dissolved in an acid, and precipitated, in order that it may resume this property.

The experiments of Mr. Lavoisier shew that pure alumine is capable of an imperfect fusion, approaching to the consistence of paste, by heat excited by a current of vital air. It is then transformed into a kind of very hard stone, which cuts glass like the precious stones, and which very difficultly yields to the file.

The mixture of chalk singularly assists the fusion of this earth: it is fusible in a crucible of chalk, according to Mr. Gerhard, but not in a crucible of clay.

The borate of soda, and the phosphates of lime, dissolve it.—See Kirwan and the abbé Mongez.

According to the experiments of Mr. Dorthes, the purest native clays, and even that which is precipitated from alum, contain a small quantity of iron in the state of oxide; and it is from this principle that the earthy smell which is emitted by moistened clays, arises: it is very difficult to deprive them of it.



V. Silex, or Quartzose Earth, Vitriifiable Earth, &c.

This earth exists nearly in a state of purity in rock crystal. But when it is required to be had in a state of purity free from all suspicion, one part of fine rock crystal may be fused with four of pure alkali. The fused mass must then be dissolved in water, and precipitated by an excess of acid.

1. Pure silex possesses a singular degree of roughness and asperity to the touch. It is absolutely void of all disposition to adhere; and its particles, when agitated in water, fall down with extreme facility.

2. Its specific gravity is 2,65.

3. Bergmann had affirmed that water might dissolve it; and Mr. Kirwan has pretended that 10,000 parts of water might hold one of silex in solution, at the ordinary temperature of the atmosphere; and might even take up a greater quantity at a higher temperature.

4. The fluoric acid dissolves it; and lets it fall when it comes in contact with water, or when it is considerably cooled.

5. Alkalis dissolve it in the dry way, and form glass; but they attack it likewise in the humid way, and are capable of dissolving one-sixth part



part of their weight when it is in a state of extreme division.

6. The burning mirror does not fuse it; but a current of vital air produced a commencement of fusion on its surface.—See Lavoisier.

Before the blow-pipe soda dissolves it with effervescence. The borate of soda dissolves it slowly, and without ebullition.

#### C L A S S I.

#### Concerning the Combination of Earths with Acids.

This class, which comprehends the combination of primitive earths with acids, naturally exhibits five genera.

#### G E N U S I.

#### Earthy Salts with Basis of Lime.

The combination of lime with various acids affords the several species of calcareous salts comprehended in this genus.

#### S P E C I E S I.

#### Carbonate of Lime, or Calcareous Stone.

The combination of lime with the carbonic  
I
acid



acid is very commonly met with, and comprehends all the stones which have hitherto been distinguished under the names of lime-stone, calcareous stone, &c.

The characters of the carbonate of lime are—

1. They effervesce with certain acids. 2. They are converted into lime by calcination.

The formation of these stones appears to us to be, for the most part, owing to the wearing down of shells. The identity of the constituent principles of shells and calcareous stones, and the presence of these same shells, more or less altered, in the lime-stone mountains, authorize us to conclude that a great part at least of the calcareous mass of our globe owes its origin to this cause only.

Though our imagination appears to assent with difficulty in referring effects of so wonderfully extensive a nature to a cause apparently so weak, we are compelled to admit it when we take a flight view of the known history of shells.

In fact, we observe the numerous class of shell animals which possess this stony covering almost at the instant of their origin. We see it insensibly become thick and enlarged by the apposition of new coverings; and this shell at length comes to occupy a volume fifty or sixty times larger than that of the animal which pro-



duced it. Let us consider the prodigious number of animals which emit this stony transudation; let us attend to their speedy augmentation, their multiplication, and the short period of their life, the mean term of which is about ten years, according to the calculation of the celebrated Buffon; let us multiply the number of these animals by the mass of shell they leave behind them—and we shall then arrive at the mass which the shells of one single generation ought to form upon this globe. If we proceed further to consider how many generations are extinct, and how many species are lost, we shall be no longer surprised to find that a considerable part of the surface of the globe is covered with their remains.

It may easily be conceived that these shells, when carried along by currents of water, must strike together, and wear their respective surfaces; and that their pulverulent remains, after being long carried about and suspended by the waters, must at last subside, and form heaps or banks of shells, more or less altered according to circumstances.

But whatever may be admitted as the origin of this stone, it is found to exist in two principal states; that is to say, either in the form of crystals, or of irregular masses.

I. Cryf-



## I. Crystallized Calcareous Stones.

A concurrence of circumstances which very seldom meet together, is required, in order that crystallization may take place. This is, doubtless, the reason why spars and calcareous crystals compose the smallest part of this genus. These crystals are found in the cavities of calcareous mountains; in the clefts which penetrate into the internal part of stones of this class; and generally in all places where waters find access, after having worn down calcareous stone to a state of extreme attenuation, nearly correspondent to solution.

Calcareous stone, in its crystallized state, presents us with several varieties of form; but the rhomboidal figure appears to be the most constant and the most general. The environs of Alais abound with rhomboidal spars of the greatest beauty; they are transparent like those of Iceland, and double objects in the same manner.

It often happens that a group of rhomboidal crystals exhibits at its surface a number of pyramids more or less prominent, which consist of the angles of rhomboids of different degrees of length. It cannot but be admitted, with Mr. Romé de Lisle, that the pyramidal form is a slight modification of the rhomboid; for if a pyramid of spar be broken, it is reduced into elements of a rhomboidal figure.



The principal varieties of the pyramidal form are deduced more especially from the number of their sides ; and when the pyramid is long and sharp, it is called dog-tooth spar, or hog-tooth spar.

Calcareous stones often affect the prismatic form ; and this is likewise attended with some varieties.

The prism is frequently six-sided and truncated ; sometimes it is terminated by a trihedral pyramid ; and when the prism is very short, and its summit is almost entirely in contact with the ground, the crystal is known by the name of Lenticular Spar.

All the varieties of form which crystallized calcareous stones have hitherto presented, may be seen in the Crystallography of Mr. Romé de Lifle.

The specific gravity of calcareous spars is about 2.700 when pure, according to Kirwan.

They contain from thirty-four to thirty-six parts of carbonic acid, and from fifty-three to fifty-five of earth, the rest is water.—See Kirwan.

Spars often exhibit a smooth uniform surface, upon which the sulphuric acid takes but slight hold : they are sometimes contaminated with iron, which gives them various tinges.

II. Calca-



## II. Calcareous Stones which are not crystallized.

Few calcareous stones affect any regular form: they lie almost always in strata, or immense blocks thrown or heaped together on the surface of the globe, in which we cannot reasonably pretend to discern any primitive design of crystallization. The notion itself which we have of the formation of these mountains, and the stratified disposition of their parts, does not allow us to discern any other effect than the natural consequence of the flowing of water, which must have occasioned a contraction, and disposed the rocks in strata or beds.

It seems to me that two very natural divisions may be established among calcareous stones which are not crystallized: for they are either susceptible of a perfect polish, in which case they are called marbles and alabasters; or they are not susceptible of this polish, in which case they are called friable earths, tufa, &c.

A. Calcareous stones susceptible of a perfect polish.

Although it be proved from the experiments of chemists, and more especially from those of Mr. Bayen, that marbles contain a greater or less proportion of clay, we are under the necessity of placing them here; because the calcareous earth predominates to such a degree, that they



cannot with propriety be placed elsewhere; and because they possess all the characters of lime-stone.

Marbles differ from other calcareous stones by the polish of which they are susceptible; and they are distinguished from each other by their colours.

White marble is usually the purest. We are acquainted with the marble of Carrara, and the ancient statuary marble of Paros.

Black marble is coloured either by a bitumen or by iron. Mr. Bayen found this metal in the proportion of five parts in the hundred. When it is veined by pyrites, it is called Portor.

There are an infinite number of varieties of coloured marble. The colouring part is in general owing to the alterations of the iron, which sometimes is obedient to the magnet, according to an observation of Mr. De Lisle. Blue and green marbles owe their colours to a mixture of ochre, according to Rinmann in his History of Iron.

The marble which presents the figure of shells appears to be formed simply out of a heap of shells connected by a calcareous cement; it is known by the name of Lumachello. That of Bleyberg in Carinthia forms one of the most beautiful species.

The



The marble which is called figured marble, exhibits either traces of vegetables, as that of Hesse; or ruins and rocks, like that of Florence. The dendrites appear to be formed merely by ferruginous infiltrations through the cracks of these stones.

Several naturalists have mentioned flexible marble. Father Jacquier described this in 1764, in the *Gazette Littéraire*; and the abbé De Sauvages has communicated to the Academy of Montpellier a description of the plates of flexible marble which are in the Palais Bourgeois.

Alabasters are calcareous stones of the nature of marble: they appear to be formed like the stalactites, and are sometimes adorned with the most beautiful colours: these in general possess a certain transparency, with a stratiform texture variously coloured, and cause a double refraction of the light when they are sufficiently transparent. In the treatise of Mr. Brissón on the specific gravities of bodies, the reader will find the result of his valuable experiments on that of marbles, alabasters, and generally all the calcareous stones.

B. Calcareous stones not susceptible of a perfect polish.

Calcareous stones which are not susceptible of



a perfect polish, are found either in masses, or in the pulverulent form; which circumstance will afford a foundation for our natural distinction.

1. Solid calcareous stone is in general the stone used for building; and this is found in several varieties, differing in fineness of grain, porosity, colour, consistence, or weight. These are gradations which establish the several qualities of stones; and are the cause why one hardens in the air, while another is decomposed. On these several accounts it is that the respective varieties are applied to various uses; and it is the business of the skilful artist who uses them to distinguish their qualities.

In the number of these stones used for building, there are some which imbibe and retain water, in consequence of which they are burst or crumbled by the frost; whereas others suffer the water which they originally contained to escape, and become harder by the contact of the air.

2. Calcareous stone is sometimes found in the pulverulent form. Chalk is of this kind; and when it is white, and very finely divided, it is formed into those masses known in commerce by the name of Spanish White. For this purpose it is agitated in a vessel with water. The foreign  
sub-



substances, such as flints, pyrites, &c. are precipitated ; the water is then decanted ; and the chalk, which is held suspended, very soon subsides ; this is dried, and divided into long square pieces, to form the Spanish White.

When a natural stream of water wears away this chalk, and afterwards deposits it, the result has been distinguished by the name of *Gurrah* ; and when this possesses a certain consistence, arising from the mixture of argillaceous and magnesian earths, it is distinguished by the name of *Agaric Mineral*.

As calcareous earth is susceptible of extreme division, the water which wears it away, and is afterwards filtered through the clefts in rocks, deposits it gradually, and forms those incrustations known by the vulgar under the name of *Petrifications*, and by that of *Stalactites* among naturalists.

These calcareous depositions very frequently preserve the form of such substances as they have covered, and present figures of moss, roots, fruit, &c. which has given rise to an opinion that those substances were transformed into stone.

The increase of stalactites being accomplished by addition to their external surfaces, their texture exhibits concentric coats of different shades,



shades, accordingly as the water may have been charged with different colouring principles.

The cavities which are frequently found in calcareous mountains are often lined with stalactites; and these grottos form one of the most striking appearances which can present itself to the eyes of the naturalist.

The grandeur of these subterraneous places, the absence of light, the feeble glimmering of a torch, which only half enlightens the surrounding objects, render these regions gloomy, majestic, and imposing. The multiplicity of figures, the variety of forms, and their resemblance to other objects, never fail to cause a high degree of astonishment in the mind of the mineralogical student. Among the infinite number of these forms, there are some which are very agreeable, such as the flos ferri, cauliflowers, lace, or fringes. Other very singular figures are likewise found, such as the priapolithes, pisolithes, oolithes, &c.

Mr. Lougeon of Ganges has observed, in the grotto called Des Demoiselles, a number of forms so varied and strange, as to exhibit a very astonishing collection.

These transudations, or rather these stony depositions, have given rise to a belief in the vegetation of stones. The celebrated Tournefort

was



was of opinion that he had observed nature in the very fact, in the famous grotto of Antiparos, where he saw inscriptions engraved in the stone, but afterwards converted into relief. Baglivi has written a treatise on the vegetation of stones, in which he cites many facts of this nature.

All the world is acquainted with the depositions of the spring in the vicinity of Clermont; but the most surprising of all petrifying waters is that of Guancavelica in Peru. Barba, D. Ulloa, and Frezier, have given us a description of it. Feuille informs us that this water rises very hot in the middle of a square basin, and becomes petrified at a small distance from the spring. The water is of a yellowish white, and the incrustations have been used to build the houses of Guancavelica. The workmen fill moulds with its water, and some days afterwards they find them incrustated with this stone. The statuaries expose their moulds in this spring, and have only to give the polish in order to render their statues transparent. All the statues used in religious ceremonies, by the catholics of Lima, are of this substance, and are very beautiful.—*Journal des Observ.* tom. i. p. 434.

In the year 1760, Mr. Vegni devised a method of making a similar use of the very white chalk which is contained in the waters of the  
baths



baths of St. Philip in Tuscany. For this purpose the water is suffered to run for the space of near a mile, in order that it may deposit the sulphur, the selenite, and the tufa which it contains; and in this purified state it is used in the fabrication of bas reliefs. It is introduced at the roof of a building, into a closet constructed of planks fitted together. The water falls from twelve to fifteen feet in height, upon a wooden cross placed on a post; by which fall it is divided, and dashes laterally against sulphur moulds, which are placed on the sides of the cabinet. In this way it deposits the particles of the earth which it contained, and the mould becomes filled. Mr. Vegni places the moulds upon pieces of wood which are moved circularly. This alabaster is as hard as marble; and the incrustation is more beautiful, and harder, in proportion as the position of the mould is more vertical, and its distance greater.

#### The Analysis and Uses of Calcareous Stone.

In 1755, Dr. Black proved that calcareous stone possesses, as one of its component parts, an air different from atmospheric air. He asserted that calcareous stone, when deprived of this air by calcination, forms lime; and that lime might again pass to the state of calcareous stone



stone by resuming the principle it had been deprived of. In 1764, Macbride supported this doctrine by new facts. Jacquin added other experiments to these; and proved that lime and alkalis owe their causticity to the subtraction of this fixed air, at the same time that he pointed out several methods of depriving them of it.

The processes which are most commonly used for the decomposition of lime-stone, are fire and acids: the first is used in the making of lime; the second in laboratories, when it is intended to procure the carbonic acid.

In order to form lime, the calcareous stone is calcined in furnaces, whose construction is varied according to the nature of the combustibles made use of.

When pit-coal is used, an inverted cone is constructed of vitrifiable stone, which is filled by alternate strata of coal and lime-stone; and the lime is taken out, after the operation, by an aperture at the top. In proportion as the mass subsides, care is taken to supply the furnace at the top, in order that the flame and heat may not be lost.

Bergmann has observed that most specimens of calcareous stone which become black or brown by calcination, contain manganese, and that the lime which they produce is excellent.

According to Rinmann, the white calcareous  
stones



stones which become black by calcination, contain about one tenth part of this substance.

Calcination deprives lime-stone of the acid and water which it contained. These two principles are evidently replaced by the matter of heat itself. The odour of fire which quick-lime emits; the light which it affords when flaked in a dark place; the colour which it communicates to the lapis causticus; the property which it possesses of producing the oxide and the glasses of lead—all prove to us, as Mr. Darcet observes in the *Journal de Physique* for 1783, that in proportion as the calcareous stone is deprived of the aeriform principle, it combines with the igneous principle, which cannot be displaced but by the way of affinities. The beautiful experiments of Meyer, when divested of all theory, prove the same thing.

It is proved, from the experiments of Dr. Higgins, that the best lime is that which is made with the hardest and most compact stone broken into small pieces, and heated slowly, until the furnace is become of a white heat. This heat must be kept up until the stone is no longer capable of effervescing with acids. The lime becomes over-burned if the ignition be carried to a greater degree; and the produce is then a frit, which is no longer capable of being divided in



water, or of resuming with avidity the principles it had lost.

When pieces of calcareous stone of different sizes are calcined, the lime will not all be of equal goodness; the small pieces consisting of over-burned lime, while the larger pieces are scarcely altered in their central parts.

The best lime is that which is the most quickly divided by immersion in water, and affords the greatest quantity of heat in this process, which causes it to fall into the finest powder. Good lime should likewise dissolve in the acetous acid without effervescence, and leave the least possible quantity of residue.

Lime continually endeavours to resume the acid and the water of which the stone was deprived by calcination: consequently, when it is left exposed to the air, it cracks, becomes heated, falls into powder with an increase of bulk, and resumes the property of effervescing. It is therefore of importance to use lime newly made, if the artist be desirous of possessing its whole force.

Lime is sparingly soluble in water, and this solution is called lime-water; the lime may be precipitated by means of carbonic acid, which regenerates calcareous stone in the form of a precipitate.



Lime water is used to indicate the presence, and determine the proportion, of carbonic acid in any mineral water.

Physicians prescribe it as an absorbent and detergent.

When lime-water is left in contact with the air of the atmosphere, a pellicle is formed at its surface, known by the name of cream of lime; this is the regenerated calcareous stone.

The superb basin of Lampi, one of the two principal reservoirs which furnish the Royal Canal of Languedoc with water, was found to leak at the junction of the stones. The skilful engineer who directs these works, Mr. Pin, caused lime to be flaked; which, passing through these small apertures, became supplied with carbonic acid, and formed a crust, or very white covering, over its whole surface: so that all the stones of this fine piece of masonry are connected together by this cement; and at present constitute one single undivided substance, impenetrable to water.

The regeneration of calcareous stone is very slowly effected by the processes hitherto described. But this may be expedited by presenting to the lime the principles with which it so strongly tends to combine: this is accordingly done in works in the large way.

Lime



Lime is usually flaked by pouring abundance of water upon it. A violent heat is thus excited; the lime falls down into powder, and a paste is afforded by strongly working the lime together in proportion as it becomes saturated.

The count Razoumoufki has taken advantage of the heat which is disengaged when lime is flaked, to combine the lime with sulphur.

The degree of heat proper to effect this combination is 70 of Reaumur. At this point the sulphur, which is placed in contact with the lime, liquefies, becomes of a red colour, and forms a true sulphure or hepar of lime.

Mortar is made simply by working sand, or other bodies insoluble in water, together with flaked lime.

We are acquainted with two kinds of sand at Montpellier; pit sand, and river sand: the former is almost always altered by a mixture of vegetable and calcareous earth, which weaken its efficacy; the second is purer, and better suited for the purpose. Instead of sand, the fragments or dust of stone may be used: the angles which these fragments present, and the roughness of their surface, contribute to give a consistence to the mortar.

The hardening of mortars appears to be owing merely to the progressive regeneration of



lime-stone. They do not obtain the greatest degree of hardness of which they are susceptible, until they have resumed all the carbonic acid of which the stone was deprived: and this operation is very slow, unless the combustion be facilitated by well-known methods, which consist in mixing substances with the mortar which contain either the carbonic acid, or a principle analogous to it, such as vinegar.

It is this regeneration of lime-stone, which is effected by the lapse of time, that explains to us why the hardest stones afford the best lime; and why old mortars are found to possess a degree of hardness which modern artists have no hopes of attaining.

The remains of ancient buildings have induced certain philosophers to conclude, that the ancients were in possession of very valuable processes for the making of mortar. Mr. De la Faye was of opinion, that those enormous masses, in which the perfection of the mechanical processes of the ancients only was admired, were made by coffer work; and he imagined that he had discovered, in Vitruvius, Pliny, and Saint Augustin, that their process to extinguish lime differed from ours; and that the great difference which appears to exist between the ancient and modern mortars depends more  
parti-



particularly upon this circumstance. These interesting researches have induced him to propose that the lime should be put into a basket, and suffered to flake in the air; as he thinks by this means it would preserve a greater degree of force, and be less weakened than by the usual processes.

Loriot has attributed the superiority of the mortars of the ancients to the means which they used to dry them speedily; and in consequence of these principles he mixes pounded bricks with flints, works the whole together with flaked lime, and dries the mass with one-fourth part of quick-lime. Care must be taken to use only lime which is finely pulverized and sifted; for otherwise the mortar would crack, and be very imperfect.

Nature sometimes presents to us a suitable mixture of lime-stone and sand, to form an excellent mortar, without any mixture of extraneous substances. Mr. De Morveau found this lime-stone in Burgundy; Mr. de Puymaurin has described a species which he found in Berne; and I have observed in Cevennes a natural mixture of this kind, in which the proportion of materials was so well assorted, that nothing more was necessary than to calcine it, and extinguish it in water, to form an excellent mortar.



## S P E C I E S II.

Sulphate of Lime, Gypsum, Selenite, Plaster Stone.

The Plaster Stone loses its transparency by calcination; at the same time that it becomes pulverulent, and acquires the property of again seizing the water of which it had been deprived, and resuming its hardness: it does not give fire with the steel, nor effervesce with acids.

We are more particularly indebted to Margraff for our acquaintance with the constituent principles of plaster; and from subsequent experiments the following proportion of the same principles has been assigned. One hundred parts of gypsum contain thirty sulphuric acid, thirty-two pure earth, thirty-eight water; it loses nearly twenty per cent. by calcination.

We begin to be equally acquainted with the formation of this stone. The chevalier De Lamanon has asserted, that the numerous quarries of plaster which are found in the vicinity of Paris, are the deposition of an ancient fluviatile lake, formed by the Seine, Loire, and Marne, which flowed off on the side of Meulan. The wrought iron, and the various remains of animals which are found at the bottom of the quarries



quarries of Mont Martre, shew that its formation is not very ancient: and the indefatigable naturalist here cited considers the selenite as originally dispersed in the water, precipitated in consequence of its sparing solubility, and heaped together in places determined by currents, waves, and other circumstances.

These facts, highly interesting as they are in the natural history of plaster, are insufficient for the chemist who is desirous of knowing likewise in what manner, and under what circumstances, the combination of the sulphuric acid and lime is made. I shall proceed to communicate some observations which our province affords.

1. I have observed in a black and pyritaceous clay of Saint Sauveur, extracted out of the work called Percement Dillon, many small needle-formed crystals of selenite, from four to eight lines in length. At the surface of the soil where the same clay is more decomposed, crystals of the same nature, but longer, thicker, and more numerous, are also found.

2. The marly and pyritous clay of Caunelle, near Mossion, abounds with beautiful crystals of rose-coloured plaster, in the form of cocks-combs, observed by Mr. Dorthes.

3. The plaster quarry of La Salle exhibits



almost alternately strata of plaster and strata of black and pyritous clay, which effloresces in the air.

4. Near the bridge of Herepian, on the declivity of Cascastel, at Gabian, and in many other places, I have constantly found crystals of gypsum mixed and confounded with pyritaceous clays.

5. The sulphureous depositions of solfatara often contain crystals of selenite.

From these facts it appears to me that the formation of gypsum may easily be conceived. It is not formed excepting in places where pyrites and clay more or less calcareous are found together; that is to say, its formation appears to be dependent on, and connected with, the presence of sulphur and lime.

Whenever, therefore, the pyrites is decomposed, the sulphuric acid which thence arises seizes the lime, and effloresces in small crystals, which are carried off by the water, and sooner or later deposited. I have observed perceptible depositions of plaster on the banks of rivulets which wash pyritous clays. I have likewise seen depositions of the same nature in rivers whose waters have been strongly concentrated by the burning heat of our summer. And consequently, if we suppose selenite to be dispersed in more considerable



considerable masses of water, there will be no difficulty in conceiving the formation of those strata which the plaster quarries exhibit.

Messrs. De Cazozy and Macquart have observed the transition of the gypsum of Cracovia to the state of calcedony. When the nucleus of calcedony is determined, it increases perceptibly in the course of time, even in cabinets; which proves that the quartzose juice, when once infiltrated into plaster, combines with the lime, and determines this transformation.

Mr. Dorthes has proved that the quartz, in cocks-combs at Passy, owed its origin to plaster; that this last substance having been carried away by solution, the quartzose juice has taken its place. Natural history exhibits several of these metamorphoses.

Gypsum is found in the earth in four different states.

1. In the pulverulent and friable form, which constitutes gypseous earth, fossil fluor, &c.

2. In solid masses, which constitute plaster stone.

3. In stalactites, or secondary depositions. In this place we may arrange the striated silky gypsums, the cauliflowers, the gypseous alabasters, and that prodigious variety of forms



which the stalactites assumes, whatever may be its component parts.

4. In determinate crystals, which usually exhibit the following forms :

1. The compressed tetrahedral rhomboidal prism.

2. The hexahedral prism truncated at its summit.

3. The decahedral rhomboid. I apprehend that the lenticular gypsum may be referred to this last form, as it appears to me to be composed of several rhomboids united together sideways. At all events I have, as the last result, obtained the rhomboidal form, by decomposing this variety.

The colour of gypsum is subject to a great number of varieties, which are the signs of various qualities relative to its uses. The white is the most beautiful, but sometimes it is grey; and in this case is less esteemed, and less valuable.

The several states of the oxides of iron, with which it abounds in greater or less quantities, constitute its rose-coloured, red, black, &c. varieties.

The specific gravity of gypsum varies according to its purity.—See Messrs. Briffon and



Kirwan: the latter found it sometimes of the weight of 2.32, and sometimes 1.87.

It is soluble in above five hundred times its weight of water, at the temperature of 60 degrees of Fahrenheit.

When it is exposed to heat, its water of crystallization is dissipated, it becomes opaque, loses its consistence, and falls into powder. If it be moistened, it becomes hard again, but does not resume its transparency; a circumstance which appears to prove that its first state is a state of crystallization.

If it be kept in a fire of considerable intensity, in contact with powder of charcoal, the acid is decomposed, and the residue is lime.

Its principles may likewise be separated by finely pulverizing it, and boiling it with alkali.

It is fusible by the blow-pipe, according to Bergmann; and in a porcelain furnace, according to Darcet.

The management of the fire in the calcination of gypsum is of great consequence. Too much heat decomposes it; and too little does not enable it to unite, and form a hard substance with water.

Calcined gypsum divides and disperses itself in water, with which it forms a paste that may be cast into every figure imaginable. We are indebted



indebted to this property for beautiful ornaments in the inside of our houses ; but it cannot be used for external decorations, because its solubility in water renders it gradually destructible by that liquid.

## S P E C I E S    III.

Fluate of Lime, Vitreous Spar, Fusible or Phosphoric Spar, Fluor Spar.

This stone is a combination of a peculiar acid, called the fluoric acid, with lime.

It decrepitates on heated coals, like the muriate of soda, or common salt. When slightly heated, it shines with a beautiful blue colour, that remains even under water, or in acids. The residue of this appearance of combustion is white and opake.

Its specific gravity is, in general, from 3.14 to 3.18 according to Kirwan.

This spar enters into fusion by a strong heat, and corrodes the crucible : it likewise fuses without effervescence with the mineral alkali, the borate of soda, and the phosphates of urine.

This stone possesses the most lively and various colours ; and it is known under the names of false emerald, false amethyst, or false topaz, accordingly as its colour is green, violet, or yellow.

The



The blue fluor spars commonly owe their colour to iron, but sometimes to cobalt. Berlin Beschäft, tom. ii. p. 330.—Green fluors are coloured by iron, according to Rinmann. The most usual form of fluuate of lime is the cubic, with all the modifications which accompany this primitive form.

When this stone is distilled with its own weight of sulphuric acid, the first product consists of elastic whitish vapours, which fill the receiver, and deposit a crust at the surface of the water, while the water itself becomes acidulous. The residue in the retort is sulphate of lime, according to Scheele. The crust which is formed on the water of the receiver is siliceous earth; and the water itself being saturated with the vapour, constitutes the fluoric acid.

The most astonishing property of this acid is doubtless that of seizing the siliceous earth, which is a constituent principle of the glass, and volatilizing it with itself.

In order to have the acid in a state of greater purity, and exempt from every mixture of filix, the operations are performed in retorts of lead; but Mr. De Puymaurin is convinced, as well as myself, that the acid even then is seldom pure, because the most beautiful fluor contains  
almost



almost always a small quantity of filex, which the acid carries with it. The whitest, the most transparent, and the most regularly-crystallized fluor, distilled on the water bath in a leaden retort, afforded me an acid contaminated by a small quantity of filex.

Mr. Meyer having used every possible means to obtain this acid in a state of great purity, is convinced that, when the acid does not find filex in the retort, it attacks the sides of the receiver, and becomes changed.

This acid may be preserved in bottles whose internal surfaces are coated with wax dissolved in oil.

The fluoric acid has some analogy with the muriatic; and some chemists have even confounded them together: but they differ essentially from each other.

The fluoric acid—1. When combined with pot-ash, presents a gelatinous substance, which when dry retains one-fifth of the alkali employed, and forms a true neutral salt. 2. It acts nearly in the same manner with soda. 3. With ammoniac it affords a jelly, which when dry exhibits all the appearances of filex. 4. When mixed with lime-water, it regenerates the fluuate of lime. 5. It does not attack gold, nor dissolve silver;  
and



and combines in preference with oxides, such as those of lead, iron, copper, tin, cobalt, and even of silver.

One part of the fluuate of lime, fused with four parts of caustic fixed alkali, forms a salt insoluble in water. The same quantity of fluuate of lime, treated in the same manner with the carbonate of pot-ash, or mild vegetable alkali, affords a soluble salt; and at the bottom of the water a calcareous earth is found, which proves that the fluoric acid is not separated but by double affinity.

This stone, which hitherto has not been employed but as a flux, or in the fabrication of ornaments, appears to me to deserve the most particular attention. Its texture seems to be lamellated like the diamond; and like that stone it is not capable of double refraction, as the abbé Rochon has observed. Its phosphorescence has likewise some relation with the combustibility of the diamond, and it has lively and varied colours. All these circumstances establish an analogy between these two substances; and might lead us to suspect that the constituent principles of the diamond exist in this stone, mixed and combined with an acid and lime, &c.

The fluoric acid possesses the very singular property of attacking glass, and dissolving and  
carrying



carrying off its filiceous part. Margraff first observed this property; but Messrs. De Puy-maurin and Klaproth have very happily applied it to the art of engraving on glass.

This acid is employed to corrode the glass, in the same manner as aqua-fortis is used to engrave upon copper.

Some authors, particularly Mr. Monnet, have endeavoured to prove that this acid was nothing else but a modification of the acid used in the decomposition of the spar. They seem to found their opinion chiefly on the circumstance, that the acid obtained exceeds in weight the spar made use of; but they have neglected the increase of weight which must arise from the erosion, dissolution, and mixture of the glass of the distilling vessels. And indeed these experiments do not appear to me to invalidate in the least the eternal truths which have issued from the laboratory of the celebrated Scheele; otherwise such modifications in the acids employed, would in my opinion afford a phenomenon still more astonishing than the existence of this peculiar acid.



## S P E C I E S    I V.

## Nitrate of Lime, Calcareous Nitre.

This salt, as well as those which remain to be treated of in the present genus, exists only in waters. Their great solubility, and their spontaneous deliquescence, do not permit them to form durable masses, or to exist in the form of stones.

The nitrate of lime is principally formed near inhabited places: old plaster affords it in abundance by lixiviation. It is one of the salts which abound in the mother waters of the salt-petre makers; and it has been found in some mineral waters.

It is usually obtained in the form of small needles, applied sideways to each other.

When a solution of nitrate of lime is concentrated to a gelatinous consistence nearly equal to that of syrup, it forms, in process of time, crystals in hexahedral prisms.

Two parts of cold water dissolve one of this salt; and boiling water dissolves more than its own weight.

Its taste is bitter and disagreeable.

It liquefies easily on the fire, and becomes solid by cooling: if it be strongly calcined, and  
2 carried



carried into the dark, it is luminous, and constitutes Baldwin's phosphorus.

It loses its acid in a violent and continued heat. When distilled in close vessels, it affords the same products as nitre by the decomposition of its acid.

Projected upon ignited coals, it detonates in proportion as it becomes dry.—See De Fourcroy.

Its acid may be disengaged by means of clay and of the sulphuric acid.

The alkalis and barytes precipitate its earth.

The sulphuric salts, and the carbonates of alkali, decompose it by double affinity.

#### S P E C I E S V.

##### Muriate of Lime, Calcareous Marine Salt.

This combination exists more especially in the waters of the sea; and contributes to give to these waters that bitter taste which has improperly been referred to bitumens that have no existence.

This salt is very deliquescent; one part and a half of water dissolves one of this salt; and hot water dissolves more than its own weight.

It may be made to crystallize by concentrating



ing its solution to the 45th degree of Baumé, and exposing it afterwards in a cool place.

With these precautions it affords a salt in tetrahedral prisms terminated by four-sided pyramids.—See De Fourcroy.

It enters into fusion with a moderate heat; but is decomposed with great difficulty. It acquires by calcination the property of shining in the dark, and is called the phosphorus of Homberg.

It is decomposed by barytes and the alkalis. The concentrated sulphuric acid, poured upon a very strong solution of muriate of lime, disengages the acid in vapours, and forms a solid precipitate; an appearance which seems in an instant to transform two liquids into a solid, and produces a very striking effect. The theory of this phenomenon is easily deduced from the very great solubility of the muriate, and the almost absolute insolubility of the sulphate which takes its place.

#### SPECIES VI.

Phosphate of Lime, Calcareous Phosphoric Salt.

This phosphate of lime has been found in Spain, in the kingdom of Estramadura, by Mr. Bowle.

It is a whitish stone of considerable density,



not hard enough to give fire with the steel. It is found in horizontal strata, repofing upon quartz, and exhibiting vertical, flattened, and clofe fibres. When thrown on ignited coals, it does not decrepitate, but burns quietly, and affords a beautiful green light, which feems to penetrate through it, and does not difappear fo quickly but that a fufficient time is admitted to contemplate its brilliancy with admiration. Before the blow-pipe it runs into a white enamel, without boiling up; whereas bones fupport the moft violent heat without fufion. Its habitudes with the nitric and fulphuric acids are the fame as thofe of calcined bones; its acid may be feparated and brought into the ftate of an animal glafs; it may be decomposed, and the phosphorus extracted.

Mr. Prouft, from whom we borrow thefe interefting details, obferves likewife that this ftone is found to compofe the mafs of entire hills in the neighbourhood of the village of Logrofan, in the jurifdiction of Truxillo, a province of Eftremadura. The houfes and the walls of enclofures are built of it.

## GENUS II.

### Earthy Salts with Bafe of Barytes.

The moft common ftate in which Barytes is found



found is in combination with the sulphuric acid.

## SPECIES I.

## Sulphate of Barytes, Ponderous Spar.

This stone is the most ponderous we are acquainted with. Its specific gravity is commonly from 4 to 4.6.

It decrepitates in the fire, melts before the blow-pipe without addition, and fluxes dissolve it with effervescence.—See the notes of the abbé Mongez\*.

Mr. Darcet succeeded in fusing it in a porcelain furnace.

It has been often confounded with gypsum and fluor spar; but the characters of these two substances are very different.

It almost always accompanies metallic ores, and it is even considered as an happy presage of finding them. Becher has affirmed that it was a certain indication *vel presentis vel futuri metalli*; and I think that there is reason to consider it as the vitrifiable stone of this celebrated naturalist. The proofs of my assertion may be seen in the preliminary ideas of my treatise

\* Manuel du Mineralogiste.



on metallic substances (in this work). The analogy between this stone and metals has been established by the experiments of Bergmann and of Mr. Lavoisier.

This stone, when rather strongly heated, exhibits a blueish light in the dark. To form these kinds of phosphori, the spar is pulverized, the powder is kneaded up with mucilage of gum tragacanth, and the paste is formed into pieces as thin as the blade of a knife. These pieces are afterwards dried, and strongly calcined by placing them in the midst of the coals of a furnace; they are afterwards cleared by blowing on them with the bellows. In this state, if they be exposed to the light for a few minutes, and afterwards carried into a dark place, they shine like glowing coals. These pieces shine even under water; but they gradually become deprived of this property, which however may be restored again by a second heating.—See De Fourcroy.

Ponderous spar is easily divided into plates by the slightest blow; and the most usual form which it affects is that of an hexahedral prism, very flat, and terminated by a dihedral summit.

Ponderous spar has been found at the distance of one league from Clermont d'Auvergne, in the form of hexahedral prisms terminated  
by



by a tetrahedral or dihedral pyramid. I have seen crystals of two inches in diameter.

It frequently happens that the form of these crystals is not very determinate; but all the stones of the nature of these exhibit a confused assemblage of several plates applied one upon another, and capable of being separated by a very slight blow. Ponderous spar is insoluble in water; and upon this property is founded the virtue possessed by the muriate of barytes, to manifest the slightest portions of sulphuric acid in any combination which contains it.

Barytes adheres more strongly to acids than the alkalis themselves do; and when the carbonates of alkalis precipitate it, the effect takes place in the way of double affinity.

#### S P E C I E S    I I.

##### *Carbonate of Barytes.*

This combination has the specific gravity of 3.773.

One hundred parts contain twenty-eight water, seven acid, sixty-five pure earth.

The sulphuric, nitric, and other acids attack it with effervescence.

Although the carbonic acid possesses the strongest affinity with this earth, it is very sel-



dom found in combination with it; and I am acquainted with its existence only on the authority of Mr. Kirwan, who affirms that Dr. Withering presented him with a specimen from Alston Moor, in Cumberland; which resembles alum, with the difference that its texture is striated, and its specific gravity is 4.331\*.

Mr. Sage analysed this stone, which was presented to him by Mr. Greville.—See the *Journal de Physique* for April 1788.

### S P E C I E S    I I I.

#### Nitrate of Barytes.

The nitric acid dissolves pure barytes, and forms a salt which crystallizes sometimes in large hexagonal crystals, and frequently in small irregular crystals.

This nitrate is decomposed by fire, and affords oxigene.

The pure alkalis do not disengage the barytes, but the alkaline carbonates precipitate it by double affinity.

The sulphuric and fluoric acids seize this earth from the nitric acid.

It has not yet been found native.

\* It is plentifully found in England, in the lead mine of Anglezark, near Chorley in Lancashire. See the *Manchester Memoirs*, vol. iii. p. 598. T.



## S P E C I E S    I V.

## Muriate of Barytes.

This salt is capable of assuming a form considerably resembling that of spar in tables or plates. It exhibits, with the earths, acids, and alkali, phenomena nearly similar to those of the nitrate of barytes.

It forms one of the most interesting re-agents to ascertain the existence of the smallest particle of sulphuric salt in any water; because, by the sudden exchange of principles, the result is ponderous spar, which immediately falls down.

It has not yet been found in a native state.

## G E N U S    I I I.

## Earthy Salts with Basis of Magnesia.

These salts were not well known before the time in which the celebrated Black proved that they ought not to be confounded with calcareous salts. They may be distinguished from these by the bitter taste which almost all of them possess.

They are in general very soluble in water. Lime-water precipitates them, as does likewise ammoniac, or the volatile alkali.



## SPECIES I.

## Sulphate of Magnesia, Epsom Salt.

This salt is frequently met with ; it exists in several mineral waters, such as those of Epsom, of Sedlitz, &c. It was first distinguished by the name of the springs which produced it ; and it is still known by the name of the bitter cathartic salt, on account of its taste and virtues.

The sulphate of magnesia, in commerce, comes either from the salt springs of Lorraine, from which this salt is extracted with a mixture of sulphur ; or otherwise from the salt works in the environs of Narbonne, where it is extracted from the mother waters which contain it abundantly.

The sulphate of magnesia, in commerce, has the form of small silky needles, very white. It does not effloresce in the air, which distinguishes it from the sulphate of soda.

The crystals of the pure sulphate of magnesia are quadrangular prisms, terminated by pyramids of an equal number of sides.

The sulphate of magnesia prepared in our salt works is sold at from thirty to forty livres the quintal ; it contains in the pound three sixteenths of sulphate of soda, two sixteenths muriate of magnesia, one sixteenth muriate of soda,  
fix



six sixteenths true sulphate of magnesia: the rest consists of salts with basis of lime.

The sulphate of magnesia, when exposed to the fire, liquefies, and loses half its weight. The remainder is dry, and requires a strong fire to fuse it.

Water dissolves its own weight of this salt, at the temperature of 60 degrees of Fahrenheit's thermometer.

One hundred parts of this salt contain twenty-four parts acid, nineteen earth, and fifty-seven water.

It exists in all the waters in the environs of Montpellier.

Sometimes it is found efflorescent upon schisti, from which it may be collected. I have found it upon a mountain in Rouergue, in a quantity sufficiently great to be collected to advantage: birds of passage devour it greedily. This salt is used in preference to others as a purgative.

#### S P E C I E S II.

#### *Nitrate of Magnesia.*

The celebrated Bergmann, who has combined magnesia with the various acids, observes that the nitric acid forms with it a salt capable of afford-



affording, by proper evaporation, prismatic, quadrangular, truncated crystals. The same chemist adds, that this salt is deliquescent. Mr. Dijonval affirms that he obtained crystals that were not deliquescent; and accident has afforded me a salt of this kind in mother water of nitre concentrated to the 45th degree of the areometer. Its form was that of prisms with four sides, very much flattened, very thick, and very short.

This salt decomposes the muriates; alkalis precipitate its magnesia, as does likewise lime.

### S P E C I E S    III.

#### *Muriate of Magnesia.*

The muriate of magnesia exists in the mother water of our salt works; its taste is very bitter.

According to Bergmann, it forms a salt in small needles, so deliquescent that it cannot be obtained but by strongly concentrating the solution, and afterwards exposing it to intense cold.

Lime-water, barytes, and the alkalis precipitate the magnesia; it may likewise be separated by means of fire.



## S P E C I E S IV.

*Carbonate of Magnesia.*

Though magnesia has the greatest affinity with the carbonic acid, I do not think that nature has ever exhibited this combination. It is obtained by precipitating the magnesia from Epsom salt, by means of the carbonates of alkali; and in this state it is called effervescent magnesia, or magnesia not calcined.

The carbonate of magnesia contains in the quintal thirty parts acid, forty-eight earth, and twenty-two water.—See Kirwan and Bergmann.

Magnesia sticks to the tongue; and assumes, in drying, a certain transparency, which it preserves until it has lost all its water, which is not easily driven off.

Fire carries off the water and the acid; and in this state the residue is called calcined magnesia.

The carbonate of magnesia is soluble in water in the proportion of several grains in an ounce of the fluid.

But we are indebted to Mr. Butini for a very singular observation—that cold dissolves more than hot water, and that the magnesia may be precipitated by heating the water which holds it in solution. Hence it arises that waters loaded



loaded with magnesia become white and turbid by ebullition.

The celebrated Bergmann had advanced that the carbonate of magnesia is crystallizable. Mr. Butini, by concentrating a saturated solution of this salt with a gentle heat, obtained groups of crystals, which, when examined by the microscope, appeared to be hexagonal truncated prisms. I have obtained similar snow-like flocks by precipitating magnesia by the addition of an alkali, drop by drop.

The carbonate of magnesia is used in medicine as a purgative. The calcined magnesia ought to be preferred as an absorbent.

#### GENUS IV.

##### Earthy Salts with Base of Alumine.

The substance which in the arts is known by the name of Clay, is a natural mixture of several earths.

Alumine, or pure clay, is capable of combining with the greatest part of the known acids; but the most common of these salts is alum.



## S P E C I E S I.

## Sulphate of Alumine, Alum.

Though alum be very commonly met with, yet the combination of principles which constitute it is not effected without considerable difficulty.

Pure clay upon which the sulphuric acid is digested, is dissolved with difficulty; and it is by no means easy to bring this combination to regular crystals. The usual product is a salt, which appears to be formed by scales applied one upon the other.

The most ordinary process to dissolve alumine by means of an acid, consists in calcining the clay, impregnating it with the acid, and facilitating its action by an heat of 50 or 60 degrees of Reaumur. But a simpler method, which I have used in my manufactory of alum, consists in presenting the acid in vapours, and under the dry form, to the clay properly prepared. For this purpose I calcine my clays, and reduce them into small pieces, which I spread over the floor of my leaden chambers. The sulphuric acid, which is formed by the combustion of a mixture of sulphur and saltpetre, expands itself in the cavity of these chambers,  
and



and exists for a certain time in the vaporous form. In this form it has a stronger action than when it has been weakened by the mixture of a quantity of water more or less considerable: so that it seizes the earths, combines with them, causes them to increase in bulk by the efflorescence which takes place, and at the end of several days the whole surface exposed to the vapour is converted into alum. Care is taken to stir these earths from time to time, that they may successively present all their surfaces to the action of the acid.

But whatever process may be used to combine the acid with clay, it is necessary to expose the aluminized earths to the air during a greater or less space of time, in order that the combination may be more accurate, and the saturation more complete.

Most of the alum in commerce is afforded by ores which are dug out of the earth for this purpose. We may reduce all the operations of this manufacture to three or four: the decomposition of the ore, the lixiviation of the ore, the evaporation of these lixiviums, and the crystallization of the alum.

1. The decomposition of the mineral is effected either in the open air without assistance, or else by means of fire.

When



When the mineral is left to decompose spontaneously, nothing more is done than to dispose the stone which contains the principles of alum in strata or layers. The pyrites becomes heated; acid is formed, which dissolves the clay; and the salt arising from this combination exhibits itself by the efflorescence of the ore. The decomposition may be accelerated by watering the heap of pyrites; but the operation may be still more abridged by the assistance of fire.—The method of applying the heat varies prodigiously. On this head Bergmann may be consulted; but in general it may be observed that it ought not to be either too strong or too weak. In the first case it volatilizes the sulphur, and in the second it retards the operation.

The ore of alum is sometimes impregnated with a sufficient quantity of bitumen to maintain the combustion.—See my Memoir on the Alum Ore of Vabrais, 1785.

2. When the ore has effloresced into alum, the salt is extracted by lixiviation. For this purpose the same water is passed over several heaps of aluminous earth, in order to saturate it. The water which is first passed over the earth dissolves in preference the vitriol, which is more or less abundant; and this salt may be separated



separated from the alum by a previous cold washing.

3. This lixivium, or saline solution, is carried into leaden caldrons, where the fluid is properly concentrated. In this part of the process it is that an accurate saturation of the alum is effected when the acid is in excess; and for this purpose alkalis are added, which serve likewise singularly to facilitate the crystallization. The celebrated Bergmann has proposed to boil clay with the solution, to saturate the excess of acid. This process seems in every point of view to be advantageous; but it appears to me to be impracticable, because the superabundant acid cannot be made to combine with the clay but by a very long ebullition; and I have observed that, by afterwards evaporating the fluid to cause it to crystallize, this clay falls down, and opposes the crystallization. I have varied the process in a variety of ways, without obtaining the success which its celebrated author predicted.

There are methods of greater or less accuracy to judge of the degree of concentration to which it is proper to carry the lixivium, in order to obtain a good crystallization: such are, the immersion of an egg in the liquid, the effusion of some drops of the lixivium on a plate, &c. Mr. De Morveau has proposed a metallic hy-

8

grometer;



grometer; but this instrument cannot be considered as very accurate; because its immersion in the liquid is proportional to the heat of the fluid in which it is plunged.

4. The lixivium is then conveyed into coolers, where it crystallizes by mere refrigeration. The pyramids of alum are constantly turned towards the bottom of the vessel, more especially those which fix themselves to the sticks which are put into the liquor to multiply the surfaces.

Alum affects the form of two tetrahedral pyramids, applied to each other base to base. Sometimes the angles are truncated, and these truncatures take place most frequently when the lixivium is slightly too acid.

This salt requires fifteen times its weight of water to dissolve it, at the temperature of 60 degrees of Fahrenheit, according to Kirwan.

Its taste is styptic: it loses its water of crystallization by heat; at the same time that it swells up, and is converted into a light and white substance, called burned or calcined alum.

If it be urged by a violent degree of heat, it loses part of its acid, and becomes tasteless. The residue is no longer susceptible of crystallization, and precipitates in the form of a very fine adhesive powder, in proportion as the water is dispersed by evaporation.



Alumine is precipitated from this solution by magnesia, barytes, and the alkalis: these last dissolve the precipitate in proportion as it is formed, if they be added in excess.

Alum is a very valuable material in the arts. It is the soul of the art of dyeing, and serves as the mordant to all colours. It is used to prepare leather, to impregnate paper and cloths intended to be printed. It is added to tallow, to render it harder; it enters into the preparation of a glue for the destruction of vermin; it is employed in England, and elsewhere, to give whiteness, and additional weight, to bread. When fused with saltpetre of the first boiling, it forms a very white crystal mineral.

The printers rub their balls with calcined alum, to cause them to take the ink. Surgeons employ it to corrode fungous or proud flesh.

#### SPECIES II.

##### Carbonate of Alumine.

The argillaceous earth precipitated from the solution of alum by the carbonates of alkalis, combines with their acid; but this salt is very rarely found in nature. I know only of the observation of Schreber which ascertains its existence. This naturalist asserted that the earth known



known by the name of *Lac Lunæ* is a true carbonate of alumine.

Although alumine be soluble in the other acids, we are very little acquainted with its combinations. It is only known that the nitric acid dissolves it, that the solution is astringent, and that it may be obtained in small styptic and deliquescent crystals.

The muriatic acid has a more evident action upon alumine. This muriate is gelatinous and deliquescent.

These salts have not been applied to any use, and they are nowhere found in nature.

#### GENUS V.

#### Earthy Salts with Base of *Silex*.

*Silex* is of all the known earths that which combines the most difficultly with acids.

We are even acquainted with no other acid than the fluoric which exerts an evident action upon it. It rises with it, and holds it in solution until it abandons it to unite with water.

Some experiments of Mr. Achard gave reason to think that the carbonic acid dissolved *silex*; but the Parisian chemists did not obtain the results announced by the chemist of Berlin. Mr. De Morveau seems to have proved that



iron and the carbonic acid were necessary to form rock crystals: but this acid does not remain united and combined with the earth; so that we have not hitherto arrived at any proof of its dissolving virtue.

## C L A S S II.

Concerning the Combination and Mixture of  
Primitive Earths, or Earthy Mixtures.

The pure and simple earths, such as we have described them, are rarely found on the surface of the globe. They are constantly mixed with each other, and form masses of greater or less magnitude, and various hardness, according to the nature of the earths, their state of division, and the character of the foreign substances which are combined with them, such as iron, bitumens, &c.

It may be easily understood that the number of compositions which can result from the mixture of five primitive earths, would be infinite, if we were to pay attention to such slight varieties as depend on the proportions of the mixture: but I shall not consider any mixtures as constituting species truly distinct, except such as differ in the identity of their constituent principles. The slight differences in the proportions of these principles



principles may indeed occasion modifications in the form, the hardness, the colour, &c. But these can never constitute more than varieties.

We shall naturally deduce the genus from the stone or earth which predominates in any mixture, and appears to communicate its own character to the total mass. In this manner we shall class among the calcareous mixtures such stones as exhibit to our observation the properties of lime-stone to such a degree, that they would be taken to be purely calcareous if the chemical analysis did not prove the existence of other principles.

The genus ought not in strictness to be taken and deduced from the earthy principle which predominates; for the character of the whole mass, or of the mixture, is very frequently given by an earth which does not form the most abundant principle; as we observe more especially in magnesian earths, where the flint predominates over the magnesia.

#### GENUS I.

##### *Calcareous Mixtures.*

According to the principles we have laid down, we must refer to this place those stony mixtures in which the properties of lime-stone predominate.



## S P E C I E S I.

## Lime-stone and Magnesia.

This mixture is very common ; almost all the calcareous stones contain magnesia. Mr. Bayen has described a variety in the *Journal de Physique*, t. xiii. which contains in the hundred parts seventy-five carbonate of lime, twelve magnesia, and thirteen iron ; it is the earth of Crentzwald. Mr. Woulfe has described another variety in the *Philosophical Transactions* for 1779. It afforded sixty parts carbonate of lime, thirty-five carbonate of magnesia, and three of iron.

The analysis which I have made of several lime-stones in our province, constantly afforded magnesia,

## S P E C I E S II.

## Lime-stone and Barytes.

Mr. Kirwan has informed us that this species is found in Derbyshire, in the form of a stone, and likewise in the earthy state. It is of a grey colour, and harder than ordinary lime-stones.



## SPECIES III.

## Carbonate of Lime and Alumine.

This mixture is frequently met with. It is commonly known by the name of Marle. The proportions of the two constituent principles are infinitely various. It is upon this proportion that the distinction of fat marles and lean marles depends, and disposes them to serve as manure for earths of different kinds. The marles are almost always coloured by iron.

They appear to arise from the decomposition of the natural mixtures of chalk and clay, and contain more or less of flint; but the analysis which I made six years ago of all the marles I could procure, convinced me that they were often nothing more than a mixture of clay and chalk. I have likewise found magnesia in marles, sometimes in the quantity of seventeen parts in the hundred; but, in general, they may be considered as formed essentially by the two earths here mentioned.

Alumine is found likewise mixed with carbonate of lime in marbles. Mr. Bayen has proved this in the second volume of the *Journal de Physique*: and I have confirmed the truth of his results by the analysis of several marbles of our province. It is even upon this principle that



we may account for the greasy polish which some of them take.

The very evident difference which may be established between the mixtures which form marle and marble, is, that the first is the immediate product of a decomposition principally effected by the alterations of the iron which it contains ; whereas the second is produced by a purely mechanical mixture of two principles already formed, which being pounded, and ground as it were together, form a compact, hard, close assemblage, susceptible of the most beautiful polish.

#### S P E C I E S    I V .

##### Lime-stone and Silex.

This species is not common. It is known under the name of Stellated Spar, Stern Schoerl of the Germans. It is opaque, and of a radiated texture or form. Mr. Fichtel found it in lime-stone on the Carpathian mountains. It effervesces with acids ; and, according to Mr. Bindheim, one hundred parts of this stone contain sixty-six carbonate of lime, thirty silex, and three iron.—See Kirwan.

The mixture of the pulverulent remains of the primitive rocks transported into our country  
by



by the rivers which rise in the Alps and the Cevennes, together with our own calcareous fragments, frequently form beds of a stone of this nature. The only difference between them is, that our mixtures exhibit a confused assemblage of all the principles which belong to the primitive rocks, such as clay, filex, and others.

## S P E C I E S V.

## Limestone and Bitumen.

This mixture is known by the name of Swinestone. It abounds in the dioceses of Alais and Uzes: I have seen the calcareous rock impregnated with bitumen in an extent of more than three leagues diameter. It is even so abundant in some parts, that it distils through the clefts of the rocks, and forms stalactitious bitumen, which the peasants collect to mark their sheep, or to grease their cart-wheels. The heat of our summer sometimes softens it to such a degree, that it flows into the roads, where it adheres to and impedes the motion of the sledges and other carriages.

In some places the stone is so well impregnated with bitumen, that it may be wrought; but the blow of a hammer causes it to emit an abominable smell. Mr. D'Avejan, bishop of Alais,



Alais, having used this stone to pave the apartments of his palace, the friction and heat disengaged so unpleasant a smell, that his successors were obliged to substitute a stone of another kind in its stead.

Mr. De la Peyrouse found this stone in large masses near Saint Beal in Comminge, at L'Estagneau, and at the mill of Langlade.

#### S P E C I E S VI.

#### Lime-stone and Iron.

Iron is almost always a constituent part of lime-stone; but it sometimes exists in such a proportion, that these mixtures constitute iron ores. Mr. Kirwan describes two of this nature; one of which contains twenty-five pounds of iron in the quintal, and the other ten. Mr. Rinmann has described stalactites which afford iron, in the proportion of from twenty-seven to twenty pounds in the quintal.\*

Calcareous iron ores are wrought in many parts of our province. I have myself obtained forty-four pounds of iron in the quintal, from a calcareous stone which abounds on the mountain of Frontignan.

It is common to find, in our calcareous mountains, hematites rich in iron, whose base is calcareous;

\* 100 Pounds



careous; we find likewise species of ludus of the same genus, and sometimes even tufa, whose formation arises from waters loaded with iron and lime.

The spathose iron ores are of the same class as those we have just treated of.

## G E N U S II.

*Barytic Mixtures.*

These mixtures are very rare, because the stone itself is scarce. We shall mention only two species.

## S P E C I E S I.

Sulphate of Barytes, Petroleum, Gypsum, Alum, and Silex.—Bergmanni Sciagr. f. 90; Kirwan Min. p. 60.

The name of Hepatic Stone (*Lapis Hepaticus*) has been given to this mixture.

The colour varies much: its texture is uniform, lamellated, scaly, or sparry. It takes the polish of alabaster.

It forms a kind of plaster by calcination, and emits a strong and fetid smell by friction.

One hundred parts of this stone contain thirty-three barytes, thirty-eight silex, seventeen alum, seven gypsum, and five petroleum.



## S P E C I E S    II.

## Carbonate of Barytes, Iron and Silex.

Mr. Kirwan has mentioned this stone on the authority of Mr. Bindheim. It is insoluble in acids, and of a sparry texture; but he is tempted to consider it as a sulphate of barytes, in consequence of the property observed by Mr. Bindheim, that it becomes soluble in acids, after having been calcined with oil.

## G E N U S    III.

## Magnesian Mixtures.

All the species comprised in this genus possess characters sufficiently striking, and easily known. They are in general greasy and soft to the touch; they may be cut with a knife, turned in a lathe, and converted into any form at pleasure. They take a tolerably good polish. Some of them are disposed into fibres; and these fibres possess, for the most part, a remarkable degree of flexibility. They stick to the tongue like clays; but do not, like them, soften in the water.



## S P E C I E S I.

Pure Magnesia, Silix, and Alumine.

## S P E C I E S II.

Carbonate of Magnesia, Silix, and Alumine.

The mixture of these three earthy principles forms talcs, steatites, pot-stones, or lapides ollares.

The difference which analysis shews between these two species, is almost entirely confined to the proportions of their constituent principles. This circumstance might appear sufficient to authorise us in considering them only as varieties of each other. But as the magnesia is pure in the talc, and in the state of carbonate in the steatites, we shall consider them as different species.

1. Pure magnesia, mixed with near twice its weight of silix, and less than its weight of alumine, forms talc. It is of a white, grey, yellow, or greenish colour; soft and soapy to the touch, composed of transparent laminæ placed upon each other. These laminæ are more tender than those of mica; they lock together, and are usually divided into rhombi, and may be crushed or scratched with the nail.

Its



Its specific gravity is 2.729.

Fire renders it more brittle and white; but it is infusible by the blow-pipe, and can scarcely be fused by the addition of alkali. The borate of soda, and the phosphate of urine, fuse it with a slight effervescence.

Muscovy talc is composed of large elastic, flexible, and transparent leaves. Plates of talc have been raised in the quarries of Vitim in Siberia which were eight feet square.

2. Steatites is usually of a greenish white: it may be easily cut with a knife; and the dust which is produced by scraping it does not readily mix with water.

Its specific gravity is about 2.433.

It is infusible alone, hardens in the fire, and becomes white. The borate of soda facilitates its fusion; but soda, and the phosphates of urine, do not perfectly dissolve it.

According to the analysis of Bergmann, one hundred parts of steatites contain eighty filix, seventeen magnesia in the state of carbonate, two alumine, and one iron.

Steatites is sometimes found in masses of indeterminate figure, and sometimes crystallized, such as that which Mr. Gerhard found at Raichewtein in Silesia. Chem. Ann. 1785.— And Mr. Romé de Lisle possesses crystals in hexagonal



hexagonal laminæ, resembling the leaves of mica.

The white steatites of Briançon is composed of irregular, friable, and semi-transparent leaves. It often incloses crystals of steatites, of a white or greenish colour, which have the form of tetrahedral prisms.

The steatites of Corsica appears to be formed by fibres placed beside each other. It has a greenish colour, and no perceptible degree of flexibility.

The steatites of Bareith is grey, compact, and solid.

That of Queen Charlotte's Bay in New Zealand is striated, green, semi-transparent, and sufficiently hard to give fire with the steel.

3. The soap-stone of China is a steatite, often striated; but it is not more unctuous than those we have already mentioned.

The steatites of Briançon forms the basis of the vegetable red.

4. The lapis ollaris, or pot-stone, is only a variety of the steatites. It does not appear to me to differ from it, excepting in being harder.

Its colour is usually greyish; but it is sometimes blackened by bitumen.

Mr. Gerhard has observed that the lapis ollaris of Sweden effervesces with acids, and contains



tains calcareous earth ; but this mixture is peculiar to it. Those of Saxony, Silesia, and Corfica do not contain it. The lapis ollaris may be wrought with the greatest facility. In the country of the Grisons, in Corfica, and elsewhere, it is turned, and formed into vessels which resist the fire, and have not the inconvenience of our glazed pottery ; it is from these uses that it has obtained the name of Lapis Ollaris, Pot Stone, &c.

## S P E C I E S    III.

Pure Magnesia combined with somewhat more than its weight of Silex, one-third of Alumine, near one-third of Water, and more or less of Iron.

This mixture forms the serpentine. It has a great analogy with the preceding substances, but is distinguished from them by a more evident degree of hardness ; by the property of acquiring a more beautiful polish ; and by a quantity of iron sufficiently considerable to afford it a peculiar character.

The serpentine is whitish, greenish, blueish, or blackish ; frequently marked with black spots ; and sometimes intersected with bands of various colours. Some serpentines are even transpa-



rent. The Royal Cabinet of Mines possess a specimen whose ground is grey, and interspersed with reddish semi-transparent and chatoyant spots.

Serpentine varies likewise in its texture.

It is compact, granulated, scaly, lamellated, or fibrous.

It takes the most beautiful polish.

The iron it contains is sometimes obedient to the magnet.

Its specific gravity is from 2.4 to 2.65.

It melts in a violent heat; but a less degree of fire hardens it.

Mr. Bayen, who has analysed the serpentine, found it to contain, in the hundred parts, forty-one filix, thirty-three magnesia, twenty alumine, three iron, and also water.

Mr Kirwan has observed, that the serpentine of Corsica contained more alumine, and less filix.

Mr. De Joubert possesses a species of serpentine which exhibits square plates on its surface.

Mr. Dorthes has observed several varieties of the serpentines on our Mediterranean coasts, and in the river of Herault, which receives them from the mountains of the Cevennes.



## S P E C I E S    I V .

Carbonate of Magnesia ; Silex, Lime, Alumine  
and Iron.

This combination exhibits several varieties, which are known under the name of Asbestos, Mountain Cork. Their texture serves to distinguish them ; but the chemical analysis confounds them together, and does not permit us to allow any other distinction than that of varieties.

## V A R I E T Y    I .

## Asbestos.

This stone is usually greenish ; its texture is sometimes fibrous and compact, and sometimes membranaceous.

Near Bagnères de Bigorre, in the mountains of the environs of Bassère, Messrs. Dolomieu and La Peyrouse found crystals of asbestos in rhomboidal parallelopipeds.

Asbestos is rough to the touch, brittle and rugged. Its specific gravity is from 2.5 to 2.8.

Fire renders it whiter and more brittle. It is infusible by the blow-pipe, according to Kirwan ; but the abbé Mongez affirms that asbestos and amianthus are fusible, and form an opaque globule,



globule, which becomes bluish. It is difficultly soluble with soda; but more easily with borate of soda and the phosphates of urine.

According to Bergmann, the asbestos contains in the quintal from fifty-three to seventy-four parts filix, about sixteen magnesia, from twelve to twenty-eight carbonate of lime, from two to six alumine, and from one to two iron.

## V A R I E T Y II.

## Mountain Cork.

This name has been given on account of a slight resemblance of this substance to cork. This stone is very light, membranaceous, flexible, and usually of a yellow colour. It may be more easily torn than broken. The diocese of Alais affords very fine specimens.

Among a very great number of stones of this nature, subjected to analysis by the celebrated Bergmann, the filiceous earth was always found predominant; and after that the magnesian, which was never less than twelve parts in the hundred, nor more than twenty-eight.



## SPECIES V.

Carbonate of Magnesia and Lime, Sulphate of Barytes, Alumine, and Iron.

This combination forms amianthus. It is composed of long flexible fibres, parallel to each other, and very soft to the touch.

They are sometimes very white, but often yellowish. The filaments may be separated and detached from each other; and may be even twisted in any direction without danger of breaking them. Their flexibility is so wonderful, that they may be formed into cloth. The ancients constructed cloths of this kind, in which they burned the bodies of the dead; and by this means the ashes were collected without mixture of those of the fuel.

Mr. Dorthes found amianthus in tufts upon calcareous stones thrown up by the sea, on which it was fixed with plants, corallines, gorgonia, &c. He believes, with reason, that this amianthus did not originate upon the stones, but that it was deposited by the water. He found likewise, on the coast, balls of the amianthus of two or three inches diameter imitating *ægagropiles*, and formed by the intertwining of the threads of amianthus; and covered with a white  
tophose



tophose substance, of the nature of that which covers the gorgonia, and is the work of a species of sea animalcule.

The fibres of amianthus are of various lengths. I have received specimens from Corfica, whose filaments were very flexible, and eight inches long. That from the Pyrenean mountains has shorter fibres.

Bergmann analysed an amianthus from the vicinity of Tarento, of which 100 parts afforded 64 filix, 18.6 magnesia, 6.9 lime, 6 sulphate of barytes, 3.3 alumine, 1.2 iron.

#### GENUS IV.

##### Aluminous Mixtures.

Argillaceous or aluminous stones are common enough. They are seldom possessed of more than a moderate degree of hardness, and are divisible in water. But the mixture of their principles is in some instances so intimate, that they possess a very strong degree of consistence.

#### SPECIES I.

Alumine, Silix, Carbonate of Lime, and more or less of Iron.

We may here place all the varieties of clay. Chemical analysis exhibits, constantly enough,



the principles whose mixture forms this species; but the proportions among these constituent principles vary so much, that the varieties of clay are almost infinite. Independent of the principles above enumerated, we sometimes find lime combined with clay, and sometimes even magnesia; and it will be easy to form various species, in proportion as the analysis of these earths shall become more perfect.

The argillaceous mixtures of which we propose at present to speak, are characterized by the following properties:—They adhere strongly to the tongue, become dry, hard, and shrink in the fire; are divided, and form a paste, with water, in which state they may be easily moulded and turned, &c. The clays in which the siliceous principle is most abundant are the driest, adhere less to the tongue, are less completely diffused in water, and crack less when dried by the heat of the fire or the sun.

Most clays contain iron; and this metal is usually the principle of their colour. From the brownish clay, in which iron is almost in the native state, to the deepest red, all the various shades are owing to the several degrees of alteration in this metal. These various changes are effected either at the surface of the globe by the immediate action of the air, which calcines the  
iron,



iron, or else in the bowels of the earth ; in which last case, the effects arise from the decomposition of water and of the pyrites. We may trace this beautiful work of nature in several pyritaceous strata in our province ; and on this subject reference may be had to my *Memoir upon the Brown Red (Brun Rouge)*, printed by Didot by order of the province.

We shall direct our attention less to the several varieties of clay than to the uses to which they are applied. The first of these uses is to form the basis of pottery.

Several species of pottery may be observed, which nevertheless differ from each other only in the degree of fineness of the earths made use of, and the care that has been taken in performing the various manipulations which they undergo.

1. The most common pottery is made with any kind of clay indiscriminately, which is mixed with sand, to render it more porous, and by this means more adapted to support the heat.

These vessels would be penetrable by water, if they were not covered with a glaze.

The glazes of pottery are usually made either with the sulphureous lead ore called *Alquinfoux*, and in England, *Potters Lead Ore*, or with the yellow copper ore. For this purpose,



these substances are reduced to powder, mixed with water, and the vessel, previously dried by a slight baking, is dipped in the mixture. The porous vessel absorbs the water, while its surface becomes covered with the pounded ore. The vessel is then carried to the furnace, and baked by a heat which vitrifies the ore upon its surface; and it is this metallic glass which forms the glaze of the potters, and is yellow or green, according to the metal made use of.

These glazes are all dangerous; because they are soluble in fats, oils, acids, &c.

The attention of intelligent manufacturers has been long directed to the methods of substituting in the place of these glazes, others which are not attended with the same danger.

We might, after the manner of the English, vitrify the surface of our pottery by means of sea salt thrown into the fire-place when the furnace is at a white heat; but this method is impracticable in most of our manufactories, because our fires are not sufficiently strong.

I have tried various methods to glaze pottery; and two among them have succeeded well enough to justify my publishing them. The first consists in mixing the earth of Murviel in water, and dipping the pottery therein: this done, they are suffered to dry; after which they  
are



are plunged into a second water, in which levigated green glass is mixed. This covering of vitreous powder fuses with the clay of Murviel; and the result is a very smooth, very white, and very cheap glazing.

The second method consists in immersing the dried pottery into a strong solution of sea salt, and afterwards baking them. The trial which I have made in my furnaces gives me reason to expect that this method may be used in large works.

I have likewise obtained a very black glazing, by exposing pottery strongly heated to the fumes of sea-coal. I have coated several vessels in this manner, by throwing a large quantity of coal in powder into a furnace wherein the pottery was ignited to whiteness. The effect is still more complete when the chimneys or tubes of aspiration of the furnace are at that moment closed, and kept so for some minutes.

I have given an account of all these circumstances, and many others, in a work presented to the Royal Society of Sciences of Montpellier; in which I have proved, from the results of my experiments in the large way, that the best mixture of our own earths is capable of affording us the most beautiful and finest pottery of every kind.



2. *Fayence\**. This does not differ from the pottery we have here spoken of, except in the degree of fineness of the earths used for its basis, and the nature of its covering or glaze.

The glazing of fayence is nothing else, as is well known, but glass rendered opaque by means of the oxide of tin. It is the glass called Enamel.

To make the fine white enamel of the potters, one hundred pounds of lead, thirty of tin, ten of marine salt, and twelve of purified potash, are calcined together. This mixture, after calcination and fusion, produces a beautiful enamel, which is applied in the same manner as the glaze before spoken of.

Bernard de Palissy excelled in the art of fayencery; and it is to him that we are indebted for our first acquisitions in this manufacture †.

3. The

\* Distinguished by us by the name of Delft Ware. T.

† I cannot resist my inclination to insert in this place a few circumstances of the life of this great but unfortunate man, who lived in the 15th century. He was a native of the diocese of Agen, and his first employment was that of surveyor or draftsman of plans: but his taste for natural history led him to abandon this employment; and he travelled for instruction over the whole kingdom, and Lower Germany. An accidental circumstance threw into his hands a cup of enamelled pottery;



3. The finest pottery is known by the name of Porcelain; it ought to be white, transparent, and of a fine grain.

The first porcelains were manufactured in Japan and China.

The celebrated Reaumur first undertook a capital series of experiments to imitate these potteries: but, deceived by the semi-transparence and  
vitreous

tery; and, from that time, his whole time and fortune were taken up in experiments on enamels. Nothing can be more interesting than the narrative which he himself has given of his labours. He exhibits himself building and rebuilding his furnaces; always on the eve of success; worn out by labour and misfortune; the derision of the public; the object of the angry remonstrances of his wife; and reduced to burn his furniture, and even the wood-work of his house, to keep his furnace going. His workman presses him for money: he strips himself, and gives him his clothes. But at length, by dint of indefatigable labour, constancy, and genius, he arrived at the desired degree of perfection; which gained him the esteem and consideration of the greatest men of his age. He was the first who formed a collection of natural history at Paris, and even gave lectures on that science; receiving half a crown from each of his auditors, under the obligation of returning it fourfold if any thing he taught should prove false. The high reputation he acquired, and the obligations under which his countrymen stood indebted to him, were not sufficient to defend him from the persecutions of the League; for Matthew De Launay, one of the greatest fanatics, caused him to be dragged to the Bastile at the age of ninety years. He signalized himself in  
his



vitreous appearance of porcelain, he imagined it to be a semi-vitrification, and attended only to the means of stopping the process of vitrification at a certain stage of its effect, or of causing it to become reversed. He succeeded in his undertaking, by filling bottles with sand and gypsum, and exposing them to a potter's furnace. I have likewise produced the same effect

his prison by acts of firmness and heroism. Henry the Third visited him, and represented his situation in these words: "My good man, if you cannot reconcile yourself to the matter of religion, I shall be compelled to leave you in the hands of my enemies."—Palissy answered, "Sire, I was perfectly ready to surrender my life for the glory of GOD. If this action could have been accompanied with any regret, certainly it must have vanished, after hearing the great King of France say, *I am compelled*. This, sire, is a situation to which neither yourself, nor those who force you to act contrary to your own disposition, can ever reduce me; because I am prepared for death; and because neither your whole people, nor your Majesty, possess the power of forcing a simple potter to bend his knee before images."—Bernard De Palissy was the first who affirmed that calcareous mountains are the remains of shells. He has exhibited such a degree of intelligence and sagacity in all his writings, that he deserves to be placed among those great men who are an ornament to our nation. The very form of his works exhibits a proof of original genius. They consist of dialogues between Theory and Practice. Practice is always the instructor; and Theory is represented as a scholar, proud of his own understanding, but indocile and ignorant.



by a very different process, though dependent on the same theory. When I concentrate my oils of vitriol in the green glass of our manufacture, that part of the retort which is continually struck by the rising oil of vitriol becomes white, and loses its transparency. This phenomenon constantly takes place, whenever the fire is raised somewhat more than usual. The retort preserves its form; but all its alkali is extracted, and there remains only the quartzose principle of a beautiful white colour, somewhat cracked like the porcelain of Japan. As the decomposition commences at the interior surface, which is immediately acted on by the vapours, this surface is frequently rendered white, and discoloured; while the exterior surface remains perfectly vitreous, and exhibits a striking contrast. For, when the interior surface of the glass is inspected, it presents a white covering applied against a surface of glass; forming, by the union of both, a thickness no greater than that of which retorts are usually made.

Father Dentrecolles sent from China the substances used in the fabrication of porcelain: they are known by the names of Kaolin and Petunzé. Similar substances were soon found in France; and our porcelain manufactories, in a short time, equalled the most beautiful productions



tions of this kind, and even exceeded them in the beauty of design and figure. The manufactory of Sèvres is at present, without contradiction, the first in the world. Nothing can equal the beauty of its paintings, the regularity of design, and the elegance of form, which are given to the vessels produced in this manufactory.

Four principal operations may be distinguished in the manufacture of porcelain.—1. The preparation, the mixture of earths, and the working of the paste. 2. The first baking, which forms the biscuit. 3. The application and fusion of the glaze and covering. 4. The art of painting, which demands a third baking, in order that the colours may be better combined, fused, and amalgamated with the glaze.

I have myself made very beautiful porcelain with the kaolin, which is found in veins in the granite of St. Jean de Gardonnenque, and the field spar so common in our mountains of Cevennes.

The quantity of porcelain which is made in China is immense. There are five hundred furnaces, and near a million of men, employed at King-to-ching, a province of Kian-si.

Our clays possess other advantages likewise: they serve, in the fulling-mills, to clean and full  
piece



piece goods. The best fullers earth is soft and soapy.

The name of tobacco-pipe clay is given to a white clay, which preserves its whiteness in the fire, and resists a violent heat.

The sealed earths, or *terræ figillatæ*, are clays upon which superstition has bestowed chimerical virtues. They are impressed with a seal, for the purpose of deceiving the public with greater certainty and effrontery.

Almost all the marles, more especially those which are found in strata, appear to me to be composed of the same principles. Much variation prevails with respect to the proportion of those constituent principles, and more especially with regard to the clay which predominates.

#### S P E C I E S II.

Alumine, Silex, Pure Magnesia, and Iron.

Mica, which results from the mixture of these principles, has been improperly confounded with talc. Mica is soft to the touch, but not greasy like talc. It possesses in general a more brilliant and less earthy colour, if I may use these expressions.

The most usual colour of mica is white or yellow,



low, inclining to red; but it has been found of a greenish, red, brown, and other colours.

Its texture likewise varies: it is scaly, lamelated, or striated.

It sometimes exhibits the form of a segment of an hexagonal prism.

It is usually found mixed with feld spar, quartz, schorl, &c. It almost always exists in the primitive rocks. Its specific gravity is from 2.535 to 3.000 when charged with iron.—Kirwan.

The colourless mica is infusible. It is only partially soluble in soda, in which it becomes divided with effervescence: it fuses in the borate of soda, and in the phosphates of urine, with scarcely any effervescence.

The coloured micas are fusible.—See De Saussure.

The fragments of mica are employed, under the name of Cats Gold or Silver, according to the colour, as a sand for drying ink upon paper.

Its yellow colour, which considerably resembles that of gold, often deceives the ignorant, who suppose that they have discovered a mine of this precious metal when they find a few pieces of this stone.

Mr. Kirwan obtained from one hundred parts of colourless mica, thirty-eight filix, twenty-eight



eight alumine, twenty magnesia, and fourteen oxide of iron.

S P E C I E S    III.

Alumine, Silix, Magnesia, Lime, and Iron.

The mixture of these principles forms the horn-stone, or horn-blende of the Germans. This stone has a close grain, is difficultly pulverized, and is slightly flattened under the hammer.

Its colour varies, which is either black or of a greenish grey; and its texture is in general either lamellated or striated.

Its general characters are, partial solubility in acids without effervescence; a degree of hardness which never amounts to that of affording fire with the steel; a specific gravity never less than 2.66, and frequently as high as 3.88; a strong earthy smell, which it emits when breathed upon, or is moistened with hot water; a tenacity under the pestle, &c.—See Kirwan, who distinguishes two varieties.



## V A R I E T Y I.

Black Horn-stone, Lapis Corneus Nitens  
Wallerii.

Its texture is either lamellated or grained. In the first case it is sometimes so soft as to be capable of being scratched with the nail. Its surface is frequently of a shining, greasy appearance; and its specific gravity is from 3.6 to 3.88.

Mr. Kirwan found that the lamellated sort contains thirty-seven parts flint, twenty-two clay, sixteen magnesia, two lime, and twenty-three oxide of iron.

## V A R I E T Y II.

Horn-stone of a Greenish Grey Colour.

This variety is either of a granulated or striated texture. Mr. Kirwan found its specific gravity to be 2.683; it is harder than the preceding.

The pale greenish horn is of this quality. Its grain is close; it emits an earthy smell, does not effervesce with acids, nor strike fire with steel. It contains, according to Kirwan, sixty-five



five parts of filex in the hundred, and its specific gravity is 6.664.

S P E C I E S    I V.

Alumine, Silex, Carbonate of Magnesia, and  
of Lime with Iron.

This species, which comprehends the slate or schistus, does not appear to differ essentially from the preceding, since its principles are the same, and there is no other difference excepting what depends on the state of the lime and magnesia; which in this last effervesces slightly with acids, according to Kirwan.

The slate is an argillaceous stone, whose principal character is that of being divisible into very thin plates, capable of being wrought, and of receiving a certain polish.

The colour of the slate is blue, of several degrees of intensity; but this colour varies, and exhibits the following shades.

V A R I E T Y    I.

Blueish Purple Slate.

This is brittle, and of a lamellated texture; does not give fire with the steel; its specific gravity is 2.876; it affords a very clear and silvery

H 2

found,



found, when divided into plates of an uniform thickness; it slightly effervesces with acids when it is reduced into powder, but not else.

It forms black scoriæ in a strong fire. Soda assists its fusion, and it is fused still more easily with the borate of soda.

From one hundred grains of this slate Mr. Kirwan obtained forty-six flint, twenty-six alumine, eight magnesia, four carbonate of lime, and fourteen iron.

#### VARIETY II.

##### Black Slate.

This receives a considerably fine polish when rubbed. The powder which is detached is white, and slightly effervesces with acids.

#### VARIETY III.

##### Blue Slate.

The blue slate contains less iron than the first variety. It is usually hard, and of a very fine grain.

#### VARIETY IV.

##### Slate of a Pale White Colour.

It is less martial than the other varieties, and is more difficultly vitrified.



Slates are used to form tablets, and to cover the roofs of houses.

## S P E C I E S V.

Alumine, Silix, Pyrites or Sulphure of Iron, and Carbonate of Lime and of Magnesia.

The schistus which results from this combination is known by the name of Pyritous Schistus.

The pyrites are sometimes dispersed in the mass, in the form of cubical crystals. Sometimes they are discovered only by analysis, or by the spontaneous decomposition of the stone.

The mountains which afford these schisti appear to me to be marine depositions. Impressions of leaves, of fishes, and other characters, are frequently observed, which leaves no doubt of their origin.

The pyrites soon effloresce when the concurrence of air and water assists their decomposition; and the results then are sulphuric salts, with bases of magnesia, alumine, iron, and lime. When the sulphate of alumine predominates, it is called aluminous schistus. Most of the alum ores wrought in Europe are of this nature. We have several in Provence which might be wrought; the schisti of Vebron in the Gevaudan, those of



Curvalle in the Albigeois, afford much alum by their decomposition.

When the magnesian principle prevails, the efflorescence consists of Epsom salt. I have discovered a mountain of this kind in Rouergue, in the neighbourhood of Saint Michael.

These efflorescences of alum or Epsom salt are always more or less abundantly mixed with the sulphates of iron and of lime; because the sulphuric acid, which is formed by the decomposition of the pyrites, attacks and dissolves all the principles contained in the schistus.

The decomposition of these pyrites may be hastened by exposure to air, calcination, &c.

#### S P E C I E S VI.

Alumine, Silex, the Carbonates of Lime and of Magnesia, the Sulphure of Iron, and Bitumen.

This schistus does not differ from the foregoing, excepting in consequence of its being impregnated with bitumen.

It is usually of a black colour, which it owes to its bituminous principle. Its consistence is various; it is sometimes divisible in flakes, and its surface is either smooth or rugged.

These are the schisti which usually form the focus of volcanos. When their decomposition

is



is favoured by air or water, a prodigious heat is excited, hydrogenous gas is produced, which exerts itself against the surrounding obstacles, and takes fire when it comes in contact with the air. It is this intestine labour which occasions the shocks and tremulous agitations that precede the eruptions of volcanos. The action of volcanos must be more lasting and terrible, in proportion as the quantity of aliment and the focus are the more considerable.

We might, in strictness, place the pit-coals here, as they do not differ from this schistus but in their greater abundance of the bituminous principle. We daily observe spontaneous inflammation to take place in heaps of pyritous coal, and the same effect happens even in the midst of the veins which are wrought. Several examples of this may be pointed out in the kingdom of France. There even exists at Cransac in Rouergue a true burning volcano. The mountain which contains the coal is prodigiously hot, and flames are perceived from time to time on its summit, which issue from its bowels. All these phenomena depend on the same cause; and from the small artificial volcano of Lemery, to the terrible eruptions of Vesuvius, there is no other difference than what consists in the magnitude of the cause.



When the earthy and metallic principles which form the basis of bituminous schisti, are strongly heated, and almost vitrified by the fire which produces their decomposition, they constitute volcanic products.

## S P E C I E S VII.

## Alumine, Silex, Lime, and Water.

This stone, which is called Zeolite, was unknown to mineralogists before the celebrated Cronstedt gave a description of it.

It is usually of a semi-transparent white; but this colour is sometimes altered by metallic mixtures, and then it assumes all kinds of tinges.

The name of Zeolite has been given to it on account of its property of forming a jelly with acids. This property has even been considered as exclusive and characteristic. But Mr. Swab has very justly observed, in the year 1758, that all zeolites do not possess this property; and Mr. Pelletier has proved, in the twentieth volume of the *Journal de Physique*, that this property is not even peculiar to zeolites.

The existence of zeolites in certain lavas has induced some naturalists to consider them as produced by the decomposition of volcanic earths.

The



The most beautiful zeolites come to us from the islands of Ferroe near Iceland. The form of this stone is constant. The radii which compose it diverge as it were from a central point, and are disposed after the manner of a fan. The radius which terminates at the external surface, is found to exhibit a trihedral or tetrahedral pyramid.

The white zeolite affects two principal forms, the cube, and the tetrahedral prism, sometimes flattened, and terminated by an obtuse tetrahedral pyramid.

Its specific gravity is from 2.1 to 3.15.

The zeolite, exposed to a strong heat, dilates, and swells more or less, according to the proportion of water it contains, and at length melts into a porous scoria. Soda fuses with it with effervescence; the borate of soda dissolves it more difficultly; and the phosphates of urine have scarcely any action upon it.

Bergmann obtained from one hundred parts of the red zeolite of Adelfort, 83 filix, 9.5 alumine, 6.5 pure lime, and 4 water.—*Letters on Iceland*, p. 370.

The white zeolite of Ferroe contains, according to Pelletier, fifty filix, twenty alumine, eight lime, and twenty-two water.—*Journal de Physique*, t. xx.

Meyer



Meyer obtained from a radiated zeolite 58.33 filix, 17.5 alumine, 6.66 lime, 17.5 water.

Mr. Kirwan rightly observes, that the crystallized species contain more water than the others.

#### GENUS V.

##### Siliceous Mixtures.

We shall place in this genus all the stones which give fire with the steel.

#### SPECIES I.

Silex, Alumine, Lime, and Iron intimately combined.

The mixture of these several earths forms the precious stones or gems. All the varieties of gems depend on their colour, hardness, brilliancy, weight, the proportion of their constituent parts, and their more or less intimate combination.

The numerous experiments of the celebrated Bergmann on precious stones have thrown the greatest light on their nature and composition. The analyses of Messrs. Gerhard, Achard, &c. by exhibiting a strict identity of principles, have confirmed to us the results of the famous Swedish chemist; and it appears that no reason-



able doubt can now be formed against those principles.

As gems or precious stones are distinguished in commerce by their colour, we shall preserve this established distinction.

#### D I V I S I O N I.

##### Red Gems or Precious Stones—the RUBY, GARNET, &c.

1. The ruby is a precious stone of a fiery red colour, electrical by friction, giving fire with the steel, the most ponderous and the hardest of precious stones. It crystallizes in long hexahedral pyramids applied base to base, without an intermediate prism.

Its specific gravity is from 3.18 to 4.283. It is not vitrified in the fire without addition; and even resists the action of the burning mirror. Flame urged by vital air easily fuses it. It does not lose its colour at the degree of heat which is sufficient to melt iron. The borate of soda and the phosphates of urine fuse it.

One hundred parts of ruby contain, according to Bergmann, forty alumine, thirty-nine flint, nine lime, and ten iron.

The lapidaries, with whom hardness and transparency are the principal characters of stones,



stones, distinguish rubies of different colours; and the inhabitants of Pegu, who consider the modifications of the colouring principle as different degrees of maturity, confound the topaz and the sapphire under the name of rubies, of which they make three varieties.

The name of Spinnelle ruby, or Balais ruby, is given to the same kind of stone, accordingly as its colour is of a pale or a deep red. This ruby crystallizes in octahedrons, and has a less specific gravity than the oriental ruby.

2. The garnet is transparent when it is not overloaded with iron. It is in general obedient to the magnet, and of a yellowish red. The forms of the garnet appear to be derived from the rhomboidal parallelopiped, terminating in six equal rhombuses.

They vary prodigiously in colour, and these varieties are—1. The red, or the carbuncle of Theophrastus, according to Hill: it has a deep red colour. 2. The Syrian garnet, of a deep red slightly tinged with yellow. 3. The violet garnet, of a beautiful red mixed with violet.

All the garnets, whether denominated oriental or occidental, rank in one of these three classes.

Garnets change in the fire into an enamel of a blackish red. They are strongly attacked by  
the



the borate of soda, and the phosphates of urine.

Garnet is found in small grains in sand stone (gres) or in schistus.

The texture of the garnet is lamellated, and its fracture vitreous.

Its hardness is inferior to that of other gems, but it exceeds that of rock crystal.

Its specific gravity is from 3.6 to 4.188.

One hundred parts of garnet contain, according to Mr. Achard, 48.3 flint, 30 clay, 11.6 lime, 10 iron.

They sometimes contain tin, or even lead; but this is seldom.—Bergmann.

## D I V I S I O N II.

Yellow Gems or Precious Stones—the TOPAZ,  
the HYACINTH, &c.

1. The topaz is of a gold colour. We are acquainted with two principal varieties: the occidental or Brazilian topaz, which has the beautiful deep yellow colour of gold; and the oriental, whose colour is lighter. The Saxon topaz resembles the latter.

The oriental topaz loses neither its colour nor its transparency in the porcelain furnace. The Brazilian topaz loses its polish, its hardness, and its transparency, but without melting.

The



The oriental topaz affects the octahedral form.

The Brazilian topaz crystallizes in rhomboidal tetrahedral prisms, grooved longitudinally. They are terminated by two tetrahedral pyramids with smooth triangular faces.

The Saxon topaz exhibits long suboctahedral prisms, terminated by hexahedral pyramids more or less truncated at their base.

The specific gravity of the oriental topaz is to that of water as 40,106 to 10,000; that of the Brazilian topaz is as 35,365 to 10,000.—See Brissón.

The analysis of one hundred parts of topaz afforded Bergmann forty-six clay, thirty-nine flint, eight carbonate of lime, and six iron.

2. The oriental hyacinth is of a reddish yellow colour.

It is usually crystallized in the form of a rectangular tetrahedral prism, terminated by two quadrangular pyramids with rhombic faces.

It loses the brilliancy of its colours by the fire. Mr. Mongez considers it as infusible by the blow-pipe. Mr. Achard affirms that he fused it in a wind furnace.

One hundred parts afforded Bergmann forty alumine, twenty-five flint, twenty carbonate of lime, and thirteen iron. That of which Mr.

Achard



Achard has given the analysis, contained 41.33 alumine, 21.66 flex, 20 carbonate of lime, 13.33 iron.

Hyacinths are found in Poland, in Bohemia, in Saxony, Velay, &c.

The hyacinth, rendered white by fire, is known by the name of Jargon. According to Mr. Lavoisier, the hyacinth of Puy in Velay becomes white in fire urged by vital air.

Its specific gravity, compared with that of water, is as 36,873 to 10,000.—See Briffon.

#### DIVISION III.

Green Gems—the EMERALD, CHRYSOLITE, BERYL, &c.

1. The Peruvian emerald is of a green colour, electrical by friction, and crystallized in hexahedral prisms, truncated flat at each extremity.

The jaspers, or green schorles, which are called prase or mother of emerald, have often been confounded with the emerald.

Crystals of emeralds are frequently found inserted in the gangues of quartz, and even of spar.

According to Mr. Sage, the more transparent emeralds are, the less their colour is changed in the fire. They become opake, and of a greenish white.



white. There are some which are reduced to enamel at their surface.

Mr. Darcet affirms, that in his experiments the emerald lost its transparency, and most of its colour, but that its form was not changed. In the experiments at Vienna in Austria, the emerald melted in twenty-four hours; and at Florence it was speedily fused by the burning mirror. Mr. De Saussure fused it by the blow-pipe into a compact grey glass; and Mr. Lavoisier, with a stream of vital air, fused it into an opaque milky bubble, whose internal part was greenish.

Its specific gravity, compared with that of water, is in the proportion of 27,755 to 10,000.

One hundred parts afforded Bergmann sixty alumine, twenty-four flux, eight lime, six iron.

Achard obtained 60 alumine, 21.26 flux, 8.33 lime, and 5 iron.

The emeralds which come from America are called occidental. Peru and the Brazils afford the most beautiful: they may be distinguished by the colour; that of Peru is of a fawn colour or appearance; the colour of the Brazilian is less lively.

The emerald is the softest of gems, and may be scratched by the topaz, the sapphire, &c.

2. The chrysolite or peridot is of a green colour, slightly inclining to yellow.

Its



Its form is that of a hexahedral pyramid with unequal sides, frequently striated, and terminating in two hexahedral pyramids.

Mr. Sage affirms that this stone suffers no alteration in the most violent heat, its colour not being so much as altered: and the same chemist pretends that Wallerius did not operate on a true chrysolite, because he affirms that it lost its colour. Messrs. Lavoisier and Erhmann fused it into a white, dirty, dull-coloured glass, by the assistance of vital air.

The specific gravity of the Brazilian chrysolite is in proportion to that of water as 26,923 to 10,000.—Brissón.

Masses of granulated chrysolite of various shades of green colour are found in the prismatic basalt, and in several other volcanic products.

These chrysolites are common in the volcanos of our province. Mr. Sage received from Auvergne an hexagonal prism six inches in diameter, formed by the union of chrysolites of different colours.

3. The beryl, or aqua marina, is of a very blueish green.

The Saxon beryl, as well as that of Siberia, sent to Mr. Sage by Mr. Pallas, exhibits hexa-



hedral, striated, truncated prisms, of a lamellated texture.

The pure beryl decrepitates in the fire, loses its transparency, and is fusible by the blow-pipe.

Its specific gravity, in proportion to water, is as 35,489 to 10,000, for the oriental aqua marina; and 27,227 to 10,000 for the occidental.—Briffon.

A blue aqua marina, in long, flattened, tetrahedral prisms, grooved longitudinally, and united sideways, is found among the granites of Spain, and on the declivity of Saint Symphorien, near Lyon. This stone is very common at Baltimore in America.

#### DIVISION IV.

##### Blue Gems—SAPPHIRE.

The colour of the sapphire is a sky blue. The sapphires of the brook d'Expailly have a green tinge, and change in the fire in the same manner as those of the Brazils; whereas the oriental sapphire is not changed in our ordinary furnaces. Mr. Erhmann caused the clear oriental sapphire, and of a perfect blue, to run into an opaque white globule by fire excited by the stream of oxigene.



The experiments of Messrs. Achard, Sage, D'Arcet, Erhmann, Lavoisier, Geyx, Quist, &c. exhibit a variety of results in the analyses of gems by fire, which can be attributed only to the manner in which they applied it; and more especially to the very variable nature of the stones upon which they made their experiments.

The oriental sapphire, and that of Puy, have the form of two very long hexahedral pyramids joined and opposed base to base, without an intermediate prism. Mr. Sage saw a sapphire in a rhomboidal cube, or six-sided figure.

The sapphire analysed by Bergmann afforded him, per quintal, 58 parts alumine, 35 filex, 5 lime, and 2 iron.

Mr. Achard obtained from his analysis 58.33 alumine, 33.33 filex, 6.66 lime, and 3.33 iron.

The specific gravity of the sapphire of Puy is in proportion to water as 40,769 to 10,000; that of the white oriental sapphire is as 39,911; and that of the Brazilian sapphire is as 31,307.



## SPECIES II.

Silex, sometimes pure, but oftener mixed with a very small quantity of Alumine, Lime, and Iron.

This species essentially comprehends quartz and rock crystal.

The name of Quartz is given to the opaque, or irregularly-figured vitrifiable stone; and that of Rock Crystal to the same stone crystallized. As the principles are nearly the same, this circumstance naturally establishes a division of these stones into two classes.

## DIVISION I.

## Rock Crystal.

Rock crystal is a stone which exhibits silex in a state more nearly approaching to purity than in any other natural substance yet observed. Mr. Gerhard has even found specimens perfectly pure; but one hundred parts of crystal, strictly analysed by Bergmann, afforded him ninety-three parts silex, six alumine, and one lime.

The ordinary form of rock crystal is that of a hexahedral prism, terminated by pyramids of  
an



an equal number of sides. The varieties of the several crystals may be reduced to this geometrical form.—Consult Romé de Lisle.

Quartz crystallizes likewise in cubes. This form exists in various specimens in the cabinets of Germany; and Mr. Macquart brought a specimen with him to France.

The formation of this crystal appears to be owing to water, for we often find this fluid in the internal part of crystals; and they are evidently formed in the clefts and cavities of the primitive rocks, by the concurrence of this agent. But hitherto we have acquired very little knowledge respecting the circumstances of this operation.

Bergmann obtained rock crystals by dissolving flint in the fluoric acid, and suffering it to evaporate slowly. I left on the tables of my cabinet of mineralogy a receiver and a retort, in which I had made the acid of fluor; and when I had occasion, two years afterwards, to inspect this apparatus, I found the receiver almost entirely corroded, and its interior surface lined with a subtle powder, in which thousands of rock crystals might be discerned.

Mr. Achard informed the public that he had obtained rock crystals by causing water impregnated with carbonic acid to filtrate through clay.



Mr. Magellan even presented these crystals to the Academy at Paris; but the experiment, though repeated with the greatest care by several chemists of the capital, was not attended with the same results.

Since that epocha, Mr. De Morveau, having inclosed rock crystals with a bar of iron in a bottle filled with gaseous water, perceived a vitreous point fixed to the iron, which he supposed to be a rock crystal formed by this operation; so that he considers iron as a necessary intermedium to enable the carbonic acid to dissolve quartz. This consequence of Mr. De Morveau appears to agree with many facts which have been collected concerning the formation of rock crystal. We see it formed in ochreous earths; and I have ochres in my collection which possess many of these small two-pointed crystals.

It appears to me that it is not necessary to seek for a solvent for flint, in order to explain the formation of rock crystal. The simple division of this earth appears to me to be sufficient for the purpose; and I could bring numerous facts to support this assertion.—See the article Crystallization.

It is proved by the observations and experiments of Mr. Genflane, that a quartzose guruh

is



is formed by simple transudation upon rocks of this nature; and the same naturalist has taken notice that, when the gurr is worn and deposited by water, rock-crystals are formed. The waters which work their way through the quartzose rocks of the mine of Chamillat, near Planche les Mines in Franche-comté, form quartzose stalactites to the roof of the works, and even upon wood. The extremities of these stalactites which have not yet assumed a solid consistence, are of a granulated and crystalline substance, easily crushed between the fingers.

In these cavities, called *craques* by the miners, a fluid gurr is often found, and still oftener crystals ready formed. I have seen at Saint Sauveur, in the work of La Boissière, near Bramebiaou, several incrustations of gurr on the sides of the gallery; and these spreading incrustations were terminated by well-formed crystals, wherever the wall overhung, or deviated from the perpendicular. This gurr, when handled, and minutely examined, had no other appearance than that of a filiceous paste of considerable purity.

The same effects appear to take place with regard to rock crystals, as with the calcareous spars. They are formed whenever their principles, in a state of extreme division and at-



nuation, are suspended by water, and deposited with all the circumstances which nature requires in order that crystallization may take place. I do not even think that it is necessary to recur to the property which water possesses of sensibly dissolving filix, to explain the formation of these crystals: and we shall refer the formation of quartzose stalactites, agates, &c. to the same cause.

Rock crystal is frequently coloured by iron, in which case it assumes peculiar shades, which have been denoted under different names. We shall place them here as simple varieties,

#### VARIETY I.

##### Red Crystal—FALSE RUBY.

It is frequently mixed with different shades. Its colour is destroyed by fire, according to Mr. D'Arcet. It is found in Barbary, in Silesia, in Bohemia, &c.

When it is of a dull red, it is called the Hyacinth of Compstella.

#### VARIETY II.

##### Yellow Crystal—BOHEMIAN TOPAZ.

It has sometimes a tinge inclining to yellow ;  
its



its colour is often internal only. It is found in Velay, near Bristol in England, &c.

## V A R I E T Y    III.

## Brown Crystal—SMOKY TOPAZ.

This brown tinge varies from a light brown to a deep black. It is affirmed that they may be rendered clear by boiling them in tallow. See *Journal de Physique*, t. vii. p. 360.

It is found in Switzerland, in Bohemia, in Dauphiny, &c.

## V A R I E T Y    IV.

## Green Crystal—FALSE EMERALD.

This is the most scarce and the most precious of coloured crystals. It is found in Saxony and Dauphiny.

## V A R I E T Y    V.

## Blue Crystal—WATER SAPPHIRE.

It does not appear to differ from the true sapphire, excepting in being less hard. I have seen a specimen which had this colour. It is found in Bohemia, in Silesia, and at Puy in Valay,



which has caused it to be called the Sapphire of Puy.

## V A R I E T Y VI.

## Violet Crystal—the AMETHIST.

Its colour is more or less deep; and it assumes a considerable brilliancy by polishing. When the crystal is only half coloured, it is called *Prime d'Amethyste*. It loses its colour by a strong fire, according to Mr. D'Arcet. This crystal is found of sufficient magnitude to form columns of more than one foot in height, and several inches in diameter.

## D I V I S I O N II.

## Quartz.

Those specimens of siliceous stone in which no regular form appears, and which we here comprehend under the name of Quartz, possess various degrees of transparency.

Its colour differs prodigiously; and it may be distinguished into varieties and shades perhaps more numerous than in rock crystal itself.

It seldom forms entire mountains, but almost always intersects, by means more or less wide, the mountains of primitive schistus. At all events,

I have



I have made this observation in every mountain of this kind which I have examined.

The blocks of quartz, detached by waters, are rolled, rounded, and deposited in the form of large stones on the banks of rivers. The same stones, more attenuated, form the quartzose pebbles; and these, still more divided, produce sand.

The stone is very refractory. It is used as the basis of bricks employed in the construction of glass furnaces. For this purpose it is calcined to whiteness, and in that state thrown into water. By this means it may be easily reduced to powder, and disposed to form a combination with clay.

Quartz, well pounded, and used in the composition of bricks, does not equally resist the impression of fire, if the precaution of calcining it, and extinguishing it in water, has not been taken. I have obtained a proof of this fact, by employing the same kind of quartz in both ways.

This sand forms an excellent mortar with good lime; and, when fused with alkalis, it produces a very beautiful glass.



## S P E C I E S    III.

Silex, Alumine, Lime, and Iron, intimately mixed.

The state of fineness in the constituent principles, and their more or less intimate mixture or amalgamation, appear to us to establish two divisions among the stones of this species. We shall accordingly distinguish them into coarser flints and finer flints. The first form gun flints, petrofilex, &c.; the second comprehend agates, calcedonies, &c.

## D I V I S I O N    I.

## The Coarser Flints.

In this place we shall arrange two stones which appear to differ only by a more or less evident degree of transparency. The filex, or flint properly so called, is semi-transparent, when very thin, as for example at its edges : the petrofilex has a more opaque colour.

1. Gun Flint.—The gun flint gives fire with steel : its colour is usually brown ; and its surface very frequently exhibits a whiter colour than the middle, and less hard than the nucleus of the stone. This external part sticks to the tongue,



tongue, and indicates a commencement of decomposition.

The abbé Bacheley has asserted that marine productions, such as polipiers, shells, &c. are capable of passing to the state of gun flint. —Journal de Physique, Supplement, 1782, t. xxv.

The specific gravity of gun flint is from 2.65 to 2.7. This stone does not melt in the fire; but it becomes white and brittle by repeated calcinations.

The common brown filex afforded by analysis to Mr. Wiegleb, per quintal, eighty filex, eighteen alumine, and two iron.

2. Petrofilex.—The colour of petrofilex is a deep blue, or a yellowish grey. It is interspersed in veins through rocks; and from this circumstance it derives its name.

Its specific gravity is from 2.59 to 2.7.

It becomes white in the fire like gun flint; but it is more fusible, for it flows without addition. Soda does not totally dissolve it in the dry way; but the borate of soda, and the phosphates of urine, dissolve it without effervescence.

Mr. Kirwan obtained from a petrofilex, used in the manufacture of porcelain by Mr. Lauraguais, seventy-two parts filex, twenty-two alumine, and six lime, in the quintal.



## D I V I S I O N   I I .

## The Finer Flints.

This division exhibits several stones, which, though distinguished by names and a different value, are nevertheless only varieties of each other. We shall content ourselves with enumerating the chief.

1. Agate.—This is a semi-transparent flint of a very fine body. Its texture is vitreous; and its hardness such that it resists the file, gives fire with the steel, and takes the most beautiful polish.

The agate, when exposed to the fire, loses its colour, becomes opaque, and does not melt.

The varieties of agates are infinite. They are founded on the colour; and they are distinguished into clouded, punctuated, spotted, irised, herborized, mossy, &c. See Daubenton. —The name of Onyx is given to that kind of agate which is formed by concentric bands. Mr. Daubenton has proved that the agate which has received the name of mossy, is really coloured by small mossy vegetations.

The purest agate is white, transparent, and nebulous. Such is the oriental agate, which besides



besides appears as if it had protuberances or knobs on its surfaces.

Its specific gravity is 2.64. I consider the agates, and the other flints concerning which we shall proceed to treat, as quartzose stalactites. The sides of geodes which are agatized, and the strata of those flints which are found in places where infiltrations produce rock crystals, appear to me conclusive in favour of this doctrine. The agates have the same relation to quartz as the alabasters to calcareous stones, and the theory of their formation is the same. Mr. Dorthes has exhibited many proofs of this theory, respecting the formation of these stones.

2. The Opal.—The semi-transparent agate of a milky whiteness, which exhibits a glittering, changeable, internal colour of a blue, red, and green tinge, is known by the name of Opal. That which comes from Hungary has a kind of greyish clay for its gangue. The most beautiful opal is the oriental opal; sometimes called the spangled opal, because its colours appear like equal spots distributed over its whole surface. These opals have received various names, according to the colours they reflect.

The chatoyant stones, or such as vary their colour according to the position of the light,  
and



and the eye of the observer, are varieties of the opal. Such are the girasol, the cat's eye, the fish's eye.

The reflected rays of the girasol are weak, blueish, and mixed with an orange yellow. This stone has been found in the lead mines of Chateaudren in Brittany. The most obvious character of the girasol is, that it exhibits in its internal part a luminous point; and reflects the rays of light in whatever position it may be turned, when it is cut into a globe or hemisphere.

The cat's eye has a point near the middle, from which proceed, in a circle, greenish traces of a very lively colour. The most beautiful stones of this kind are of a grey and mortdoré colour. They come from Egypt and Arabia.

The fish's eye does not differ from the cat's eye excepting in its colour, which is blueish: it is found at Java.

3. Calcedony.—The calcedony is a semi-transparent agate of a milky whiteness, differing from the foregoing in not possessing the chatoyant property, or changeableness of colour.

It has been found in the mines of Cornwall, in stalactites of singular elegance. These calcedonies are almost always covered with protuberances



berances like the stalagmites. The protuberances appear to be formed by the successive apposition of several strata or coatings.

In Monte Berico, in the territory of Vicenza, geodes of calcedony are found which inclose water. They are called Enhydria.

I possess, in the Mineralogical Cabinet of the province, calcedonies of Auvergne, which appear to be crystallized like rock-crystal. The crystals have all the fat and unctuous appearance of the same balls which are dispersed on the rock; but, when they are broke, it is seen that the appearance arose from a covering of calcedony over the crystal of quartz.

Mr. Bindheim analysed calcedony, and found, in the centenary, 83.3 flint, 11 lime, 1.6 alumine, and a small quantity of iron.—Schrift. Natur. For. Freu. t. iii. p. 429.

Mr. Darcet did not succeed in fusing calcedony, but it lost its colour.

Calcedony has often a shade of blue, yellow, or red.

Mr. De Carozzy and Mr. Macquart observed in Poland the transformation of gypsum to the state of calcedony.—See the *Essai de Minéralogie* par M. Macquart, premier mémoire.

4. Cacholong. The white and opaque calce-  
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dony is known by the name of Cacholong. Its texture resembles that of quartz, and it becomes white in the fire. This stone is capable of a fine polish. It is found on the banks of a river named Cach, near the Kalmouks of Bucharina, in whose language the word *cholong* signifies stone.

An imaginary value has been given to a modification of the cacholong, which has the property of becoming transparent after having been plunged in water. This is called Hydrophanes, Lapis Mutabilis, Oculus Mundi. Mr. Dantz brought hydrophanes to Paris, which became transparent when plunged in water.

Mr. Gerhard, on the 28th of August 1777, read to the Academy of Berlin, Observations on the Hydrophanes. He found that this stone contained two-thirds of clay, and one-third of flex. This celebrated naturalist affirms that the hydrophanes was known to Boyle, who saw one of them about the size of a pea sold in London for two hundred pounds sterling.

The hydrophanes is fusible in the fire. Soda dissolves it with effervescence; the borate of soda, and the phosphates of urine, without effervescence.

5. Carnelian. Sardonyx. The carnelian is a species of agate, nearly transparent. It is called

Car-



Carneole when it has the colour of flesh. Its hardness varies prodigiously. Those which are white or yellowish are not sufficiently hard to give fire with the steel. When ignited it loses its colour, and becomes opake. The most beautiful specimens resemble the garnet. Its specific gravity is from 2.6 to 2.7.

The sardonix is a semi-transparent flint, of an orange colour, more or less deep. It is knobbed like the calcedony; and possesses the hardness and specific gravity of that stone. Its habitude in the fire resembles that of the agate. In the Royal Wardrobe of France there are vessels of sardonix of an astonishing magnitude and beauty. The famous murrhine vases were of sardonix. Sage, t. ii. p. 163.

S P E C I E S IV.

Silex, Alumine, and Iron.

Jasper is one of the hardest stones we are acquainted with. It is susceptible of the finest polish; and its colour varies prodigiously, which has occasioned it to receive the names of Sanguine Jasper, Green Jasper, Flowered Jasper, &c.

Mr. Wedgwood assured Mr. Kirwan that jasper hardens in the fire without melting; and



Mr. Lavoisier could not obtain a perfect fusion by the assistance of oxigenous gas. The surface only becomes vitreous.

Mr. Gerhard asserts that some species are fusible; and Mr. Kirwan attributes this property to the mixture of lime and iron which produces the fusion.

Its excessive hardness has induced the savages of Canada to avail themselves of it in the fabrication of the heads of javelins.

Mr. Dorthes has found, among the worn stones of the Mediterranean shore, javelin-heads of porphyry, jasper, horn-stone, schorl, variolite, &c. probably fabricated by the ancient inhabitants, the Gauls.

These javelin-heads are commonly known by the name of Thunder-stones, and are distinguished by lithologists by the name of Ceraunites.

#### SPECIES V.

Silex, Alumine, Lime with a small portion of Magnesia, and Iron.

This species comprehends all the schorls, and most of the volcanic products. As the tourmaline is evidently nothing more than a variety of the schorl, we shall place it here, though analysis



lysis has not discovered an atom of magnesia in it, and the nature of its principles confounds it with precious stones. Moreover, by placing it between these and the schorls, it possesses a situation assigned to it as well by its natural characters as by its constituent principles.

I. The Tourmaline. — This stone possesses the transparency of the schorl. Its appearance and fracture are vitreous, its texture lamellated, its hardness so considerable as to cut glass. When heated to the two-hundredth degree of Fahrenheit, it becomes electrical: a stronger fire deprives it of this property. It is fusible by the blow-pipe, with ebullition; the pure tourmaline was melted into a black glass, in the experiments of Mr. Lavoisier.

Tourmalines have been found in the island of Ceylon, in Tyrol, and in Spain.

Its form is that of a nine-sided prism, terminated by two flat trihedral pyramids. Mr. De Joubert possesses one whose prism is seven inches and a half long, and eleven inches in circumference.

The prismatic tourmaline has no electric effect but according to the direction of its column; the sphere of activity of the Spanish tourmaline is more extensive than that of Tyrol.

The valuable researches of Bergmann upon



this stone may be consulted in his dissertation concerning its analysis. Mr. Tofani has annexed a set of interesting notes to his translation of this work.

The results of Bergmann's analysis exhibit its component parts in the following proportion :

1. The tourmaline of Tyrol contains alumine forty-two, flix forty, lime twelve, iron fix.

2. The tourmaline of Ceylon, alumine thirty-nine, flix thirty-seven, lime fifteen, iron nine.

3. The tourmaline of Brazil, alumine fifty, flix thirty-four, lime eleven, iron five.

The specific gravity of the tourmaline of Ceylon is 30,541, that of Spain and of Tyrol is 30,863, water being 10,000.—See Briffon.

II. Schorl. The distinct properties of schorl are, an appearance of semi-vitrification, fusibility in a moderate fire, and hardness approaching to that of crystal.

There are few stones which exhibit a greater variety of form or colour.

They enter into the composition of porphyry, of serpentine, of granite, and are very frequently found with the magnesian stones.

We shall distinguish the schorls into crystallized and irregularly-shaped schorls.



A. All the varieties which depend upon colour may be reduced to four.

1. Black Schorl.—The black schorl is found chiefly in granites. It has almost always the form of prisms more or less perfect. The number of sides of these prisms is various: they are sometimes grooved; they sometimes terminate in trihedral obtuse pyramids, placed in contrary directions; in some places they are found several inches long, and the union of these prisms frequently forms groups of several inches in diameter. Their black colour is more or less deep. When urged by fire, they become resolved into a black uniform glass of an imperfect fluidity like paste.

The analysis of the black prismatic schorls of Gevaudan afforded me, per quintal, fifty-two filix, thirty-seven alumine, five lime, three magnesia, and three iron.

2. Green Schorl.—This variety exhibits the same form, and the same modifications; but the most common of its crystallizations is that of a tetrahedral prism, terminating in short pyramids likewise tetrahedral.

3. Violet Schorl.—This variety was discovered in 1781 by Mr. Schreiber, below the Grotto of Aunis, situated at the distance of one league from Bourg d'Oisan in Dauphiny. Mr. De la



Peyrouse likewise found it at the Peak of Dretliz, in the Pyrenean Mountains.

This schorl possesses a certain degree of transparency. It is crystallized in rhomboides; its texture is lamellated; two of the rhomboidal planes of each pyramid have their faces striated parallel to each other.

Schorl loses its colour in the fire, and one thirteenth of its weight; it becomes of a greyish white: and with a stronger degree of heat it swells up, subsides, and forms a black enamel.

Its specific gravity is 32,956, according to Briffon.

4. White Schorl.—This variety has been found in the mountains of Corsica, Dauphiny, and the Pyrenées. It is of an opaque white colour, and vitreous appearance; and is found in crystals on the surface of certain stones of the nature of lapis ollaris. I have seen a layer of this schorl between amianthus and the lapis ollaris. It melts in the fire into a white enamel.

The analysis of this schorl from the Pyrenean Mountains afforded me, per quintal, fifty-five parts filix, twenty-two alumine, thirteen magnesia, and seven lime.

B. The schorl in connected masses nearly approaches the jasper in its external characters. It may be distinguished however by its fracture, which



which is of a dryer grain, and exhibits a disposition to crystallization. This stone serves as the basis to several porphyries. The variolite of Durance, a stone singular on account of the superstitions to which it has given rise, is a schorl in the mass, covered with grains of the same nature as the ground, but of a clearer green.

Mr. Dorthes has observed variolites on the coast of our Mediterranean sea; and affirms that this stone in its decomposition undergoes changes of colour, which succeed each other in the order of the solar spectrum.

III. Volcanic products.—The principal products of volcanos are basaltes, lava, and terra pozzolana. These substances are absolutely of the same nature; but they are principally distinguished by the name of Basaltes when their form is regular. When they have no determinate figure, they are denominated Lavas; and when considerably attenuated they are distinguished by the name of Terra Pozzolana.

Basaltes is distinguished into the prismatic basaltes with a number of fides, from three to seven; the basaltes in tables; and the spherical basaltes.

Lava is distinguished into compact lava, porous lava, twisted lava, lava in tears, &c.

Several naturalists have classed the basaltes with



with the schorls, and some of them have assigned the same origin to both. It appears nevertheless to be generally agreed that basaltes is a product of fire.

It sometimes differs from schorls in its chemical analysis, and also in the circumstance of its not always affording magnesian earth.

The colour of basaltes is of a deep green, almost constantly covered or enveloped with a ferruginous crust less black than the internal part. The iron is in the state of ochre.

Its form is constantly prismatic, which is the natural effect of the contraction which it suffers in cooling.

Basaltes is converted by fire into a most beautiful black glass. This property, which is admitted by every chemist, induced me to fuse it, and blow it into bottles.

The attempt was perfectly successful at the glass-house of Mr. Gilley of Allais, and at that of Mr. Giral of Erepian. I still preserve the first vessels which were blown of this substance: they are of the most beautiful black, astonishingly light, but without transparency. Encouraged by this first success, I requested Mr. Castelveil, the proprietor of another glass-house, to undertake some experiments; and in consequence of various trials we succeeded in fabricating bottles  
of



of an olive green, in which the most extreme lightness, and a truly astonishing degree of solidity, were united. Pounded basaltes, soda, and sand, in nearly equal proportions, formed their composition. The properties of these bottles, as proved by my own experiments, as well as by those which Mr. Joly De Fleury, at that time comptroller-general, ordered to be made, render them of the greatest value in commerce; and Mr. Castelveil was unable to supply the numerous orders he received. This manufacture supported itself with success for two years; but at the end of that time the superiority of the bottles ceased to be the same; the manufacturer received the reproaches of the consumer; this superb establishment gradually fell off, and was at length abandoned.

Since that period I have made several experiments in the large way, from which I have obtained results that may be of service to such as are desirous of following this manufacture.

1. The nature of the combustible used in glass-houses has a prodigious effect in modifying the results of experiments. The same basaltes which Mr. Castelveil considered as too refractory in his furnace heated by wood, was found of too fusible a nature by Mr. Giral, who was in the habit of using pit-coal in his glass works. The former



former manufacturer accordingly made his glass by adding soda to the lava, whilst the latter mixed it with a very refractory sand.

2. The same lava, fused without addition, may be blown in one glass-house, and not in another. This irregularity appeared to me at first to depend essentially on the skill of the workmen; but I have been since convinced that it is totally independent of that circumstance.

In a furnace which is strongly heated, the fused lava sometimes becomes fluid like water, and drops from the iron tube as soon as it is collected. The same lava, when fused in other furnaces, will preserve a sufficient degree of consistence to admit of being blown. I am myself well assured that the lava might be wrought in any glass-house whatever, provided the moment was seized in which the paste was neither too fluid nor too thick to be wrought; but these attentions are too delicate, and too minute, to be observed in works in the large way.

3. The hardest basalt affords the most beautiful glass. When it is contaminated with foreign principles, such as the nodules of lime, the glass is brittle, and has not a sufficient connection of its parts. This circumstance, in my opinion, was the cause of the bad quality of the glass,



glass, which produced the failure in Mr. Castelveil's manufactory.

4. I have seen very hard basaltes interspersed with black infusible points, insomuch that these points became enveloped in the vitreous paste without any perceptible alteration. The volcanic mountain of Escandorgue near Lodeve afforded me this variety of basaltes.

In the article Verrerie of the *Encyclopédie Méthodique*, may be seen the various results which we have obtained with Mr. Allut, in several experiments made in common in the royal glass works of Bousquet and elsewhere.

I shall conclude, from the observations which my experiments have hitherto afforded—

1. That lava may be used as a flux in glass-houses to diminish the consumption of soda. This is the single purpose I at that time proposed to myself, and I have clearly accomplished it. 1. By the results of experiments which have shewn that refractory sand becomes fused in the glass furnace by a mixture of lava. 2. By the effects obtained in all the works in the large way, in which the addition of lava permitted a diminution in the proportion of soda.

2. It is very difficult to establish a rigorous process, applicable to all circumstances, by which lava may be wrought without addition. My  
bottles



bottles into which the lava entered as a component part, were scarcely known, before it was published that they were formed of lava without addition; nothing more being said to be required than to fuse the lava in order to form bottles. This strange report affected me very little in the principle; because I had neither spoken, written, nor printed any thing which was capable of giving authority to such an error: and I was content to reply to all persons who demanded information, by informing them that experience had taught me that an addition of lava diminished the proportion of soda in the composition of glass, and that this new principle rendered the bottles lighter and stronger.

3. That the only advantage which can be derived from fusing lava without addition, is to pour it out into moulds, to form paving stones, chimney jams, &c. The facility with which it is fused by the assistance of pit-coal, would render these works of small expence; and it might easily be decorated by incrusting it with metallic colours.

4. That the difference in the nature of volcanic products produces such a variety in the results of their fusion, that I consider it as impossible to assign a constant and invariable process, by which the same result may infallibly be



be obtained. This circumstance renders it necessary to make preliminary trials in all cases wherein it is intended to use basaltes in the fabrication of bottles.

The basaltes has been considered as similar to a stone known by the name of Trapp: it resembles it in several essential properties; the colour, form, weight, and the nature of the component parts of each, appear to authorize us in confounding them together, as Bergmann has proved by the fine comparison he has made of these two stones, in his analyses of the volcanic products of Iceland. But this same chemist has shewn that they differ in several other points of view.

The trapp exhibits no character which can give ground to suspect that its origin is volcanic; it is found in Sweden, in the primitive mountains, and upon strata of granite and schistus, and sometimes even upon banks of calcareous stone.

The trapp of the mountains of Westrogothland is usually in the form of a square irregular cube; and it is indebted for its denomination to this resemblance to the steps of a stair-case. It likewise exhibits the form of a triangular prism, though seldom; and sometimes it resembles immense columns.

、 The



The trapp afforded Bergmann the same principles, and nearly in the same proportion, as the basalt. The difference is scarcely the hundredth part; and this variation is frequently found in pieces of the same basalt.

## S P E C I E S VI.

Silex, Lime, Magnesia, Iron, Copper, and the Fluoric Acid.

This combination forms the chrysoprase. Its colour is a semi-transparent apple green, and it is harder than the fusible spars and quartz of the same colour.

The fire deprives it of its green colour, renders it white and opaque, and forms by the assistance of vital air, a compact and milky globule.—See Erhmann.

Mr. Achard obtained, in the quintal of this stone, 95 parts silex, 1.7 lime, 1.2 magnesia, 0.6 copper.

## S P E C I E S VII.

Silex, the blue Fluide of Lime, with the Sulphate of Lime and Iron.

This singular combination forms the Lapis Lazuli, or Azure Stone.

Its colour is of a beautiful opaque blue, which it preserves in a strong heat, and does not suffer any alteration in this respect by the contact of air.

The



The powder of this stone makes a slight effervescence with acids; but after calcination it forms a jelly with acids, without exhibiting any previous effervescence.

The powder of this stone forms the valuable colour known by the name of Ultramarine. The price of this colour is proportioned to its intensity; and its value is accordingly least when it is mixed with pyrites, because these bodies diminish the vivacity of its colour.

This stone affords water by calcination, and when distilled with the muriate of ammoniac, it forms martial flowers; which proves, according to Mr. Sage, that its colour is owing to iron.

The azure stone is fused by a strong heat into a whitish glass; and by the assistance of oxigene it forms a white transparent globule inclining to green, without internal bubbles, and not obedient to the magnet.

The specific gravity of the lapis lazuli of Siberia is 29,454.—See Briffon.

Plates of the lapis lazuli may be seen upon almost all richly decorated altars; it is likewise made into toys.

Margraff obtained from this stone calcareous earth, gypsum, iron, and filex. Mr. Rinmann has discovered that it contains the fluoric acid.



## S P E C I E S VIII.

Silex, Alumine, Barytes, and Magnesia.

This stone is known by the names of Feld Spar, Rhomboidal Quartz, Spathum scintillans, Petuntze.

It very frequently forms one of the principles of granite, and the crystals, which are found separate, arise from the decomposition of this primitive rock.

The texture of feld spar is close, lamellated, and it is less hard than quartz.

It fuses without addition into a whitish glass. I have nevertheless observed a very great variety in the feld spars, with regard to their habitude in the fire. That of Avene, which is in the form of whitish crystals mixed with quartz, afforded me a transparent glass of extreme hardness by the simple addition of one-third of lime: whereas that of Esperon, treated in the same manner, did not exhibit the smallest sign of fusion.

The specific gravity of white feld spar is 25,946.—See Briffon.

Feld spar exhibits several varieties in its form and colour.

Most of the pieces of feld spar inclosed in  
granite



granite have a rhomboidal form; and when this primitive rock becomes decomposed, the crystals of feld spar are detached, and remain confounded with the rubbish. The granites of our province, almost all of them, contain these crystals, some of which are an inch and a half in diameter.

Feld spar has been found crystallized in tetrahedral prisms, terminating in pyramids with four sides.

I possess some specimens of feld spar of Auvergne, whose tetrahedral prisms are flattened and terminated by a dihedral summit.

The principal shades of colour in feld spar are white, rose-colour, and chatoyant, or of changeable colours.

The white transparent feld spar is very rare; there is a piece in the Royal Cabinet of the Mineral School, which comes from Mount St. Gothar.

One hundred parts of white feld spar contain about sixty-seven filix, fourteen alumine, eleven barytes, and eight magnesia.

The rose-coloured feld spar is not very scarce. Our mountains exhibit much of it. It abounds with iron, which is in the state of ochre. Some experiments have shewn me that this variety is more fusible than the others. My analyses have



even exhibited a larger portion of magnesia; and its consistence appears to me to be less firm than that of other specimens.

Feld spar is composed of rhomboidal laminæ, which give it the property of exhibiting various colours, in a greater or less degree. Large pieces of feld spar have been found on the northern coast of Labrador, worn down by the waters into a round form, of a blueish grey colour, and exhibiting the most agreeable change of colours, according to the variation of position. The colours are a beautiful celestial blue, shaded with green. This stone is known by the name of Labrador Stone. Granites are frequently found in which the feld spar exhibits its changeable colours without being wrought.

### C L A S S   I I I .

Concerning the Mixture of Stones among each other. Stony Mixtures. Rocks.

The mixture of the primitive earths with each other forms the stones we have hitherto treated of; and these stones, united and connected together, or as it were joined by a cement, constitute the numerous class of pebbles or stones, concerning which we shall proceed to treat. It is evidently seen that the mixture of various  
stones



stones has been produced, either by revolutions which have reversed and confounded the whole surface of countries, or by the action of waters, which have successively formed the strata of rounded flints spread over the surface of the globe, and have afterwards deposited in their interstices that earthy matter which has connected them together. These mixtures have afterwards acquired a degree of hardness; and at length appeared to form one single substance.

We shall establish our genera upon the presence of such stones as predominate; and the species will be deduced from the variety of stones mixed with that which determines the genus.

#### GENUS I.

Rocks formed by the Mixture of Calcareous  
Stones with other Species.

Though the basis of calcareous stones enters into the composition of the greater part of lithologic substances, we find few rocks which can be ranged in this class.



## S P E C I E S I.

Carbonate of Lime, and Sulphate of Barytes.

Mr. Kirwan observed compound stones in Derbyshire, formed of chalk intermixed with nodules of ponderous spar.

## S P E C I E S II.

Carbonate of Lime and Mica.

The green marble or Cipolin of Autun is of this kind. It is composed of eighty-three parts carbonate of lime, twelve green mica, and one iron.—*Journal de Physique*, t. xii. page 55. Calcareous stones are found in Italy, which exhibit brilliant specks of mica, and are known by the name of Mafigno.

## S P E C I E S III.

Mixtures of Calcareous and Magnesian Stones.

Sulphate of lime, fluat of lime, and carbonate of lime are found mixed with steatites, serpentine, talc, amianthus, and asbestos. Such is, for example, the white marble interspersed with spots of steatites, and described by Cronstedt.



## S P E C I E S IV.

## Calcareous Stones, and Fragments of Quartz.

Quartz is sometimes found in a calcareous cement. Sweden and Siberia exhibit several marbles which give fire with the steel. The calcareous grit, so common in the southern part of our kingdom, is of this species. The sand is composed of fragments of quartzose flints, rounded and connected by a calcareous gluten or cement. By digestion of grit-stone in an acid, the calcareous cement becomes dissolved, and the proportion which the sand bears to the whole may then be easily determined.

This grit-stone is seldom hard enough to be used in building, or in paving.

At Nemours, and at Fontainebleau, this stone has been found crystallized in perfect rhomboids: the cabinets of naturalists are enriched with superb samples of this kind.

Lime-stone has likewise been found serving as a cement for feld spar, schorl, &c.; but this is somewhat rare.

Mr. De Saussure has described a stone whose elements are quartz and spar.

Our shores afford pebbles of hard marble of



a light-grey colour, interspersed with feld spar and quartz.—See Dorthes.

## GENUS II.

Compound Stones formed by the Mixture of Barytic Stones with other Stones.

As ponderous spar is of considerable scarcity, and is almost always found alone, this genus will not be numerous.

## SPECIES I.

Ponderous Spar mixed with a small Quantity of Calcareous Spar.

The dioceses of Alais and of Uzes afforded me this species; and I have myself observed in the latter rhomboids of calcareous spar, so well mixed with the laminæ of ponderous spar, that it is impossible to separate them without destroying the stone. It was among the veins of ponderous spar which are found on the road from Portes to Alais, that I saw this mixture.



S P E C I E S    II.

Ponderous Spar and Serpentine.

Mr. Kirwan describes a species of serpentine with spots of barytes.

S P E C I E S    III.

Ponderous Spar and Fluor Spar.

The ponderous spar of Auvergne is mixed with fluor spar : I have many specimens of this.

S P E C I E S    IV.

Ponderous Spar and Indurated Clay.

This is the Kros-stein of the Germans. The clay which forms the ground is grey, and includes a ponderous spar of a white colour, which is disposed in this clay in the form of veins, that might be taken at first sight for vermiculites, or, in general, for the remains of some organized substances. This stone is found at Bochnia in Poland.

S P E C I E S    V.

Ponderous Spar and Quartz.

I have in my collection several specimens, in  
which



which the ponderous spar is disposed in stars upon a matrix of the nature of filex.

#### S P E C I E S VI.

##### Ponderous Spar and Lava.

The extinct volcanos of the diocese of Beziers have afforded me lavas, partly decomposed, whose surface exhibits radii of ponderous spar, which, at first sight, I took to be zeolite.

#### G E N U S III.

##### Rocks or Stones formed by the Mixture of Magnesian Stones with other Kinds.

#### S P E C I E S I.

##### Magnesian Stones mixed together.

The same rock often exhibits the various known magnesian stones in contact with each other. Thus we see the asbestos placed beside the amianthus, the serpentine in contact with the asbestos, the steatites in contact with talc.

#### S P E C I E S II.

##### Magnesian Stones and Calcareous Stones.

The serpentine has been found spotted with calcareous spar, and gypsum.



## S P E C I E S    I I I .

## Magnesian Stones and Aluminous Stones.

Steatites is frequently mixed with clay. Its fibres are found bedded in an argillaceous substance. Steatites and serpentine are sometimes mixed with schistus.

## S P E C I E S    I V .

## Magnesian Stones and Siliceous Stones.

Serpentine is found mixed with veins of quartz, feld spar, schorl, &c.

Asbestos and amianthus are often confounded, and sometimes incorporated in quartz and rock-crystal.

Mr. De Sauffure has described a compound stone, of which the quartz is white, and the steatites green.

At Sterzing in Tyrol, is found a rock formed by schorl and serpentine.

In the county of Mansfeld in Saxony, a rock has been discovered, composed of jasper and asbestos.



## GENUS IV.

Rocks or Stones formed by the Mixture of  
Aluminous Stones with other Species.

## SPECIES I.

## Schistus and Mica.

This mixture forms several primitive mountains. The mica is sometimes in plates of a certain thickness, but most commonly in small fragments; and the stone assumes a brilliant argentine appearance, which renders these stones agreeable to the sight. In this last case, the stone is nearly white, sonorous, and splits into leaves; whereas it is blackish, and less hard, when the mica is dispersed through it in large grains.

These kinds of micaceous schisti do not become spontaneously decomposed. They differ essentially from the pyritous schistus, whose formation appears to be posterior to that of the present species.

This micaceous schistus is a primitive stone. It does not include minerals, or at least very rarely; and it is not spontaneously decomposed.



## S P E C I E S    II.

## Schistus and Garnet.

The schistus frequently contains garnets, which rise in protuberances in its texture, and separate its strata from each other. The garnet is crystallized, and one would be disposed to affirm that this stone had increased, and almost vegetated, in the other, which serves as its covering. It is probable that the garnet has been enveloped by this paste of schistus; or that it was formed while the stone was still almost in the fluid state.

I found this schistus filled with garnets in the bed of the river Bramabiou, in the diocese of Alais.

## S P E C I E S    III.

Schistus, Mica, and Quartz mixed in small Fragments.

The Germans call this compound stone by the name of Gneiss. It deserves to be included among the quartzose and siliceous stones; but as it nearly approaches the primitive schisti we have just treated of, we shall follow the natural method in classing it here.

The



The texture of this stone varies greatly. It sometimes forms a rock in which neither ground nor fibres can be distinguished; in other specimens it appears to be divided into filaments twisted in a thousand manners, and it frequently exhibits a lamellated hard texture.

It is found in large masses of a greyish green colour, with its surface shining, and polished like the slate; and it appears to be merely a fine-grained granite, the minuteness of whose parts has suffered them to take the foliated form of the schistus.

Mr. Weigleb has analysed that of Friburg.

#### SPECIES IV.

##### Schistus and Schorl.

The mixture of these two stones is common enough. The schorl is sometimes dispersed in very minute filaments, which give a blackish tinge to the mass. Its form is often prismatic; in which case the fibres of the schistus, and the long crystals of the schorl, form the prism by their reunion.

A schistus has been found in the Pyrenean mountains, in which the schorl is spread from space to space in the form of oblong bodies, and equally dispersed over the whole mass.



## SPECIES V.

## Clay and Quartz.

This constitutes the argillaceous grit-stone, or the stone in which fragments of quartz are united together by an argillaceous gluten.

Several varieties of grit-stone may be distinguished. It is often found in irregular, coarse, and compact masses, which are made into mill-stones, or used for paving, &c.

The magnitude of the fragments of quartz renders the surface more or less rugged; and it is this which renders it proper for certain operations of trituration.

When its grain is finer, it is made into grind-stones. It is by virtue of their quartzous principles that grind-stones emit such numerous sparks, when struck with the steel, or when they are moved with rapidity against any tool of that metal.

Argillaceous grit-stone is sometimes of a scaly texture: the *Cos Turcica* of Wallerius, and the stone used for sharpening scythes, are of this kind.

Fine grit-stone, composed of impalpable particles, is known by the name of Tripoli, from the part of Africa whence it first came. It is  
now



now found in Rouergue, in Brittany, Germany, and elsewhere.

The porous grit-stone called Filtering-stone, on account of its use, is of the same nature.

Quartz is sometimes mixed with mica. Our province contains it in various places.

The mica is likewise found mixed,

1. With feld spar, according to Ferber and Kirwan.

2. With schorl, at Mont-hykie in Dalecarlia in Sweden, and at Sterzing in Tyrol.

3. With garnets, at Paternion in Carinthia, and at the Carpathian mountains in Hungary.

4. With garnet and schorl, at Greyner.—See Muller.

5. With quartz, feld spar, and schorl. This composition forms one of the most common granites.

The mixture of these stones, varied in the proportion of their principles or elements, forms the numerous variety of granites; and the several colours likewise modify them exceedingly.

#### GENUS V.

Compound Stones formed by the Mixture and Re-union of Quartzose Stones with each other.



## S P E C I E S I.

## Quartz and Schorl.

The quartz is, in general, white in this stone, and the schorl of various colours. Some of the paving-stones of London are of this sort, according to Kirwan. The schorl is likewise found in crystals within the quartz.

## S P E C I E S II.

## Quartz and Feld Spar.

A stone of this nature was brought me from the neighbourhood of Avenes. The mountain from which the specimen was detached, contains about one-third of quartz. The rest of the rock consists of rhomboidal feld spar, of no great firmness of texture, and constantly exhibiting the rhombus in its fracture.

I possess a very fine specimen of a similar rock, which was sent me from Fahlun in Dalecarlia.

## S P E C I E S III.

## Grit-stone and Garnet.

I have received from the mines of Tallard, near Gap in Dauphiny, grit-stones with garnets of one or two lines in diameter interpersed.



These garnets are dispersed through the whole mass, at the distance of three or four lines from each other.

## S P E C I E S IV.

## Quartz, Feld Spar, and Schorl.

This mixture is common, and forms great part of the granites on our globe.

The proportion of the elements of this rock varies greatly, but the forms of the stones which compose it are not less variable. The schorl is frequently crystallized in prisms; the feld spar almost always exhibits rhomboidal laminae, on breaking the stone; the quartz very seldom exhibits determinate figures, but it has nevertheless been found in superb crystals at Alençon and elsewhere.

The colour of these stones, likewise, exhibits an infinity of shades. The schorl is usually black; but it is sometimes found green, and even white, as in some granites brought from Spain. The feld spar is commonly of an ashen grey; but it has been observed of a flesh-colour, of a milk-white, of a dull red, &c. The most common appearance of the quartz is, that of a fat and vitreous substance. It is sometimes black.



## S P E C I E S V.

Fragments of Quartz united by a Siliceous Cement.

We may here class the quartzose plum-pudding stones. The cement which unites these pebbles of quartz, which are commonly rounded, is the paste of petrosilex. Some of these pudding-stones are so compact, and their fracture is so uniform, that they are capable of the most beautiful polish, and produce a very happy effect by the variety of colour of the several flints connected by the same gluten.

## S P E C I E S VI.

Jasper and Feld Spar.

This rock is known by the name of Porphyry. The jasper composes the ground, and the feld spar is interspersed in small needles, or in flat parallelopipedons.

The colour of porphyry varies prodigiously. The feld spar, which enters into its composition, is either white, or yellowish, or red; but the name of the porphyry is always dependent on the colour of the jasper. The jasper is some-



times green and sometimes black, and in some instances red; which establishes a great number of varieties.

As this stone is susceptible of the most beautiful polish, it has been employed as an ornament; and our temples, as well as private houses, are decorated with it.

Mr. Ferber found in Tyrol porphyry in prismatic columns, resembling those of basalt; a circumstance which affords a further degree of probability to the opinion of such as have considered porphyry to be a volcanic production.

Porphyry is found in Egypt, in Italy, in Germany, in Sweden, in France, &c. Mr. Dorthes has brought, from various mountains in Auvergne, specimens of porphyric basalt in tables and in masses, containing crystals of feldspar, well formed, and little altered.

He observed that the rocks of Chevenon, an ancient convent of Gramontin, at the distance of one league from Artonne in Auvergne, were very beautiful porphyry. Mr. Guettard found it likewise in the forest of Esterelle in Provence.

Mr. Dorthes has described more than twenty varieties of porphyry thrown up in pebbles by the Mediterranean upon our coasts, whither they



they are brought by the Rhone. In many of these are found transparent quartz with the prismatic form, and crystallized feld spar.

Porphyry fuses into a black globule, marked with white points.

The specific gravity of red porphyry is 27,651, and that of green 26,760.—Briffon.

Porphyry sometimes contains schorl. Wallerius has described it "*Porphir rubens, cum spatho scintillante albo, et basalto nigro.*"

S P E C I E S VII.

Jasper and Garnet.

This stone has been discovered in Iceland: the ground is a green jasper, which includes ferruginous garnets crystallized, and of a red colour.

S P E C I E S VIII.

Jasper and Calcedony.

The Mountain of Giants, in Bohemia, affords this stone. It has likewise been found in the Carpathian mountains, near Kaskau in Hungary. A stone has likewise been observed at Oberstein, in the Palatinate, composed of agate and jasper.



## S P E C I E S IX.

## Jasper and Quartz.

This compound stone, called *Saxum Sibericum* by Linnæus, has been found in Siberia, and also near Stutgard in the Duchy of Wirtemberg.

## S P E C I E S X.

## Jasper, Quartz, and Feld Spar.

This stone is found in the environs of Geneva. Its ground is a jasper, or rather a petrofilex, black, opaque, and very hard. This matrix is interspersed with small rectangular crystals of white feld spar, and rounded grains of transparent quartz. Mr. De Saussure, who has described this species, places it among the porphyries.

## S P E C I E S XI.

## Schorl, Garnet, and Tourmaline.

Mr. Muller has discovered in Schneeberg, a mountain of the territory of Sterzing in Tyrol, a rock of this kind, containing large crystals of tourmaline, which include small crystallized garnets, transparent, and of a red colour.

Mr.



Mr. Ferber affirms that he found between Faltfritz and Carnowitz in Stiria, detached pieces of green fchorl, which inclose large red garnets: he adds, that this fchorl is sometimes scaly, and of a micaceous texture.

Mr. De Sauffure has found in the environs of Geneva, stones worn round by water, which were composed of fchorl in the mass, and garnet.

The Mediterranean Sea throws up on our coast many varieties of rounded pebbles of porphyry, which have fchorl for their basis.

GENUS VI.

Super-compound Stones, or such as result from the Mixture and Re-union of several different Genera.

SPECIES I.

Petrofilex, Alumine, and Calcareous Spar.

This stone is found at Schneeberg in Saxony.

SPECIES II.

Clay, Steatites, and Calcareous Spar.

This species, as well as the two following, are comprised under the name of Saxa Glandulosa. The steatites, the spar, and the other substances



are dispersed in the matter which forms the ground of this rock.

S P E C I E S   I I I .

Clay, Zeolite, Schorl, and Calcareous Spar.

S P E C I E S   I V .

Clay, Serpentine, and Calcareous Spar.

S P E C I E S   V .

Serpentine, Mica, and Calcareous Spar.

Mr. Ferber has described this last species under the name of Polzevera ; a denomination suggested to him by the place where it is found, See his Letters on Italy.

S P E C I E S   V I .

Serpentine, Schorl, and Calcareous Stone.

This stone furrounds the veins of the mine of St. Simon and Jude, at Dognasta, in the Banat of Temesward : it is likewise found in the copper mines of Saska ; and at Hoferöschlag, near Schemnitz, in Lower Hungary.



## SPECIES VII.

Steatites, Mica, and Garnets.

This stone is found at Handol in Jempter-land, towards the north of Sweden.—Born. Ind. Foss. par. ii.

## SPECIES VIII.

Steatites, Mica, and Schorl.

This stone was found at Salbury in Westman-land, a province of Sweden.—Born. Ind. Foss. par. ii.

## SPECIES IX.

Garnets, Quartz, Mica, and Serpentine.

This contains a small quantity of pyrites. It is found at Pusterthal in Tyrol.—See Bruckmann.

## SPECIES X.

Feld Spar, Quartz, Mica, Steatites.

Several granites are formed by a mixture of this nature. Such are found at Sunneskog in Sweden, and at Guten Hoffnangsbau near Altwoschitz



wofchitz in Bohemia: it is the *granites steatite mixtus* of Born.

#### S P E C I E S   X I.

Quartz, Mica, and Clay.

This rock is the matrix of the ore of tin at Platte, and at Gottesgab in Bohemia.

#### S P E C I E S   X I I.

Quartz, Clay, and Steatites.

This is found at Mount St. Godard in Switzerland.

#### Concerning the Diamond.

The diamond forms an appendix to the history of stones. Its combustibility is a character which prevents its being assimilated to any known species.

The diamond was long considered as the hardest and most ponderous of stones, as well as the only one which did not cause a double refraction; but subsequent observations have destroyed these early notions. The adamantine spar appears to equal it in hardness; the oriental ruby, and the jargon of Ceylon, are more ponderous; and the oriental precious stones



stones exhibit one refraction only, as does likewise the phosphoric spar.

This precious stone is found on the coast of Coromandel, and principally in the kingdoms of Golconda and Visapour. The earth which serves as its gangue is red, ochreous, and soils the fingers.

The general process of exploring the diamond mines or earths, consists in mixing the earth with water, after which the fluid is poured off, and the sand which remains at the bottom is dried by the strong heat of the sun.—See the Memoirs of the Comte Marechal.

Other naturalists inform us that, when the earths have been washed, the residue is left to dry, and is sifted in baskets made for the purpose. The workmen afterwards seek for the diamonds with their hands.

Diamonds in their native state are covered with two crusts; the one earthy, and the other sparry.—Romé de Lisle.

When lapidaries undertake to work them, they are obliged to find the grain of the stone, in order to split or cleave the diamond. If the fracture be not uniform, they call the stone a *diamond of nature*. The hardness of the diamond is such, that it resists the most highly tempered steel;



steel; which circumstance renders it necessary to attack it by diamond powder.

The manner or form in which diamonds are cut, distinguishes them into rose diamonds, and brilliants, or brilliant diamonds. The brilliant diamond is cut into facets on both sides. The variety of forms given to these facets, and their different inclinations with respect to each other, multiply the refractions, and contribute to afford those reflections, and streams of pure and vivid light, which characterize the diamond.

The diamond is divided into two kinds; the oriental diamond, and the Brazilian diamond.

The oriental diamond crystallizes in octahedrons, and exhibits all the varieties of this primitive form.

The Brazilian diamond crystallizes in dodecahedrons. It is neither so hard, so heavy, so perfect, nor so valuable, as the oriental diamond.

The colourless diamond has a specific gravity which is in proportion to that of water as 35,212 to 10,000. Mr. Briffon has derived this specific gravity from an experiment on the *Pitt* diamond of the French crown. A cubic foot of this diamond would weigh two hundred and forty-six livres, seven ounces, five gros, sixty-nine grains,

The



The diamond is sometimes coloured green, violet, black, &c. The green are the most esteemed, because they are the most scarce. The weight of coloured diamonds is more considerable than that of the white diamond; because it is augmented by the weight of the colouring principle, which is of a metallic nature.

The brilliancy, hardness, and scarcity of the diamond have preserved it in the most extravagant degree of estimation. A diamond is said to be of a fine water when it presents no defect or spot; and the price is proportioned to its purity.

When a diamond is without fault, its value is estimated according to its weight; which is determined or divided into carats, each carat being equivalent to about four grains.

The most beautiful diamonds hitherto known are—1. The two in the crown of the king of France; one of which is the Grand Sancy, weighing one hundred and six carats; and the other the Pitt, which weighs seven gros, twenty-five grains and one sixteenth. It is fourteen lines long, thirteen and a half broad, and nine and one-third thick. 2. The diamond which at present belongs to the Czarina weighs seven hundred and seventy-nine carats. The Empress purchased it in 1772 for twelve tons of gold



gold (100,000 florins), and granted a pension of four thousand roubles to the seller. It is pretended that this fine diamond was one of those which ornamented the eyes of the famous statue Scheringham, which has eight eyes and four heads; and that it was carried off by a French deserter who had procured himself to be appointed as a guard to the temple of Brama. This diamond was at first sold for fifty thousand livres, afterwards for about four hundred thousand livres, and was at length purchased by the Empress of Russia.

The combustibility of the diamond is a phenomenon sufficiently interesting to induce us to give a faithful extract of the principal experiments which have served to advance our knowledge upon this subject.

Boyle observed, long since, that the diamond, exposed to a violent fire, emitted acrid vapours.

The emperor Francis the First caused crucibles to be exposed to a reverberatory fire for twenty-four hours, into which vessels the value of six thousand florins in diamonds and rubies were put. The diamonds disappeared, but the rubies were not altered. These experiments were repeated with great expence; and it was ascertained that the diamond lost its polish, scaled off, and was dissipated.

The Great Duke of Tuscany, in 1694, caused experi-



experiments to be made by Mr. Averoni and Targioni, by the mirror of Tschirnausen, and it was found that the diamonds disappeared in a few minutes.

In 1772, these experiments were resumed by the skilful chemists of Paris—Darcet, the Comte de Laragais, Cadet, Lavoisier, Mitouard, Macquer, &c. The details of the interesting experiments made on this subject may be seen in the volumes of the Academy of Sciences, and the *Journaux de Physique*, of that year. We shall simply relate the results.

1. Messrs. Darcet and the Comte de Laragais proved that the diamond is volatilized in balls of porcelain.

2. Mr. Macquer took notice that the diamond dilated and swelled up; and that a blue flame was observable on its surface during the combustion.

3. Messrs. Lavoisier and Cadet proved, that the combustion of diamonds in closed vessels ceased as soon as the oxigene was destroyed; and that the diamond did not burn but in proportion to the oxigene present, like all other combustible substances. The jewellers, who expose their diamonds to very violent fires to render them colourless, are careful to wrap them up in such a manner as to secure them from the contact of air.

Mr.



Mr. De Saussure burned a diamond by the blow-pipe: Mr. Lavoisier has proved that, when it is exposed to the burning glass, a dust arises which precipitates lime-water.

The diamond is therefore a combustible substance, which burns in the same manner as other bodies. This strict and accurate consequence is deduced from all the experiments which can be imagined to acquire a perfect demonstration.

Within a few years chemists have discovered a very singular stone, to which the name of Adamantine Spar has been given by Bergmann.

It is black, and so hard that its powder may be used to cut the diamond; from which circumstance it has obtained its name.

It crystallizes in hexahedral or six-sided prisms, two of which are large, and four small.

Its specific gravity is 38,732 with respect to water, which is assumed at 10,000. See Brissón.—The cubic foot weighs two hundred and seventy-one livres, one ounce, seven gros, sixty-three grains.

The most violent fire produces only a slight softening of this spar, according to the experiments of Mr. Lavoisier.

The analysis made by Mr. Klaproth of this stone, has exhibited a peculiar earth, which is suspected to be likewise one of the principles of precious stones, &c.



# GENERAL VIEWS

RESPECTING

THE DECOMPOSITIONS AND CHANGES TO WHICH THE  
STONY PART OF OUR GLOBE HAS BEEN SUBJECTED.

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IF it were permitted to man to follow, during several ages, the various changes which are produced on the surface of our globe by the numerous agents that alter it, we should at this time have been in possession of the most valuable information respecting these great phenomena : but thrown, as we are, almost by accident, upon a small point of this vast theatre of observation, we fix our attention for a moment upon operations which have employed the works of nature for ages ; and we are unable either to perceive or to foretel the results, be-



cause several ages are scarcely sufficient to render the effects or changes perceptible. Nature never ceases to exist : her activity has been coeval with the existence of matter ; her operations are not circumscribed within limited times ; she disposes of whole ages in the arrangement of her combinations ; while man can command no more than a few instants, and himself disappears at the moment wherein he has proceeded so far as to connect a few facts together. Hence, no doubt, it arises, that nature is incomprehensible in some of her operations, and inimitable in all those which require a long series of time.

It must be allowed that those men who, by the mere efforts of their imagination, have endeavoured to form ideas respecting the construction, and the great phenomena, of this globe, have numerous titles to our indulgence. In their proceedings we behold the efforts of genius, tormented with the desire of acquiring knowledge, and irritated at the prospect of the scanty means which nature has put in its power : and when these naturalists, such as Mr. De Buffon, have possessed the power of embellishing their hypotheses with every ornament which imagination and eloquence can furnish, either as instruments of illusion or entertainment, we ought to consider ourselves indebted to them.

For



For our part, we shall confine ourselves to exhibit a few ideas respecting the successive decompositions of our planet, and shall endeavour to avoid every departure from observation and matter of fact.

The slightest observation shews us that living beings are kept up and perpetuated only by successive decompositions and combinations. A slight view of the mineral kingdom exhibits the same changes ; and our globe, in all its productions, presents continual modifications, and a circle of activity, which might appear incompatible with the apparent inertia of lithologic products.

In order to arrange our ideas with greater regularity, we may consider this globe in two different states. We will first examine the primitive rock which forms the nodule or central part. This appears to contain no germ of life, includes no remains or part of any living being, and from every circumstance appears to have been of primitive formation, anterior to the creation of animated or vegetating bodies. We shall pursue the various changes which are daily produced by the destructive action of such agents as alter or modify this substance.

We shall then proceed to examine what stones have been successively placed upon this, and



what are the decompositions to which these secondary rocks have been subjected.

1. The observations of naturalists all unite to prove that the central part of the globe consists of the stone known by the name of Granite. The profound excavations which the art of man, or currents of water, have made in the surface of our planet, have all uncovered this rock, and have been incapable of penetrating lower: we may therefore consider this substance as the nucleus of the globe; and upon this substance it is that all matters of posterior formation rest.

Granite exhibits many varieties in its form, composition, and disposition: but it in general consists of an assemblage of certain filiceous stones, such as quartz, schorl, feld spar, mica, &c.; and the more or less considerable magnitude of these elements of granite, has caused it to be divided into coarse-grained granite, and fine-grained granite.

It appears to me that there is no denying but that these rocks owe their arrangement to water: and if we may be permitted to recur, by an effort of the imagination\*, to that epocha in which, according

\* This is the first and the last supposition in which I shall indulge myself. It is a conjecture however which is indifferent with



according to sacred and profane historians, the water and earth were confounded, and the confused mixture of all principles formed a chaos, we shall see that the laws of gravity inherent in matter must have carried it down, and necessarily produced the arrangement which observation at present exhibits to us. The water, as the least heavy, must have purified itself, and arisen to the surface by a filtration through the other materials: while the earthy principles must have precipitated, and formed a mud, in which all the elements of stones were confounded. In this very natural order of things the general law of affinities, which continually tends to bring together all analogous parts, must have exerted itself with its whole activity upon the principles of this almost fluid paste; and the result must have been a number of bodies of a more definite kind, in crystals more or less regular: and from this muddy substance, in which the principles of the stones were confounded that compose the granite, a rock must have been produced, containing the elementary stones all in possession of their distinct forms and charac-

with respect to the basis of the subject itself; since it relates only to an hypothesis respecting the manner in which a rock might be formed that at present exists, and whose decompositions alone can form the subject of our observations.



ters. In this manner it is that we observe salts of very different kinds develope themselves in waters which hold them in solution ; and in this manner it still happens that crystals of spar and gypsum are formed in clays which contain their component parts.

It may easily be conceived that the laws of gravitation must have influenced the arrangement and disposition of the products. The most gross and heavy bodies must have fallen, and the lightest and most attenuated substances must have arranged themselves on the surface of the foregoing : and this it is which constitutes the primitive schisti, the gneis, the rocks of mica, &c. which commonly repose upon masses of coarse-grained granite.

The disposition of the fine-grained granite in strata or beds, appears to me to depend on this position, and the fineness or tenuity of its parts. Being placed in immediate contact with water, this fluid must naturally have influenced the arrangement which it presents to us ; and the elements of this rock being subjected to the effect of waves, and the action of currents, must have formed strata.

The rocks of granite being once established as the nucleus of our globe, we may, from the analysis of its constituent principles, and by attending



tending to the action of the various agents capable of altering it, follow the degradations to which it has been subjected, step by step.

Water is the principal agent whose effects we shall examine.

This fluid, collected in the cavity of the ocean, is carried by the winds to the tops of the most elevated mountains, where it is precipitated in rain, and forms torrents, which return with various degrees of rapidity into the common reservoir.

This uninterrupted motion and fall must gradually attenuate and wear away the hardest rocks, and carry their pulverulent parts to distances more or less considerable. The action of the air, and the varying temperatures of the atmosphere, facilitate the attenuation and the destruction of these rocks. Heat dries their surface, and renders it more accessible and more penetrable to the water which succeeds; cold divides them, by freezing the water which has entered into their texture; the air itself affords the carbonic acid, which attacks the lime-stone, and causes it to effloresce; the oxigene unites to the iron, and calcines it: insomuch that this concurrence of causes favours the disunion of principles; and consequently the action of water, which clears the surface, carries away the



products of decomposition, and makes preparation for a succeeding process of the same nature.

The first effect of the rain is therefore to depress the mountains. But the stones which compose them must resist in proportion to their hardness; and we ought not to be surprised when we observe peaks which have braved the destructive action of time, and still remain to attest the primitive level of the mountains which have disappeared. The primitive rocks, alike inaccessible to the injury of ages as to the animated beings which cover less elevated mountains with their remains, may be considered as the source or origin of rivers and streams. The water which falls on their summits, flows down in torrents by their lateral surfaces. In its course it wears away the soil upon which it incessantly acts. It hollows out a bed, of a depth proportioned to the rapidity of its course, the quantity of its waters, and the hardness of the rock over which it flows; at the same time that it carries along with it portions and fragments of such stones as it loosens in its course.

These stones, rolled along by the water, must strike together, and break off their projecting angles: a process that must quickly have afforded those rounded flints which form the pebbles of rivers.



rivers. These pebbles are found to diminish in size, in proportion to the distance from the mountain which affords them; and it is to this cause that Mr. Dorthes has referred the disproportionate magnitude of the pebbles which form our ancient worn stones, when compared with those of modern date: for the sea extending itself formerly much more inland, in the direction of the Rhone, the stones which it received from the rivers, and threw back again upon the shores, had not run through so long a space in their beds as those which they at present pass over. Thus it is that the remains of the Alps, carried along by the Rhone, have successively covered the vast interval comprised between the mountains of Dauphiny and Vivarais; and are carried into our seas, which deposit them in small pebbles on the shore.

The pulverulent remains of mountains, or the powder which results from the rounding of these flints, are carried along with greater facility than the flints themselves: they float for a long time in the water, whose transparence they impair; and when these same waters are less agitated, and their course becomes slackened, they are deposited in a fine and light paste, forming beds more or less thick, and of the same nature as that of the rocks to which they owe their origin. These strata gradually become



come drier by the agglutination of their principles; they become consistent, acquire hardness, and form filiceous clays, filex, petrofilex, and all the numerous class of pebbles which are found dispersed in strata, or in banks, in the ancient beds of rivers.

Mr. Pallas has observed the transition of clay to the state of filex in the brook of Sunghir, near Wolodimir. Mr. J. W. Baumer has likewise observed it in Upper Hesse.

The mud is much more frequently deposited in the interstices left between the rounded flints themselves, which intervals it fills, and there forms a true cement that becomes hard, and constitutes the compound stones known by the name of pudding-stones and grit-stones; for these two kinds of stones do not appear to me to differ but in the coarseness of the grain which forms them, and the cement which connects them together.

We sometimes observe the granite spontaneously decomposed. The texture of the stones which form it has been destroyed; the principles or component parts are disunited and separated, and they are gradually carried away by the waters. I have observed near Mende, towards Castelnouvel, the most beautiful kaolin on the surface of a granite, in a state of decomposition; and



and this same rock is decomposed in several other parts of our province. It appeared to me that the feld spar was particularly subject to be altered the first.

Most siliceous stones, formed by the deposition of fluviatile waters, and hardened by the lapse of time, are easily subjected to a second decomposition. Iron is the principal agent of these secondary alterations; and its calcination, determined by air or water, produces a disunion of principles. Nature may be observed in this process, by an attentive examination of such alterations as gun flints, variolites, porphyries, jaspers, and the like, are subjected to.

The decomposition of flints, calcedonies, agates, and generally all stones of this kind which possess a certain degree of transparency, appears to me to be referable to the volatilization of the water, which forms one of their principles, and is the cause of their transparency.

These stones may be considered as commencements of crystallization; and, when the water is dissipated, they effloresce after the manner of certain neutral salts. Hence it arises that the decomposition is announced by opacity, a white colour, loss of consistence, and hardness; and terminates by forming a very attenuated powder, sometimes of extreme whiteness. It is this decom-



decomposition, more particularly, which forms clays.

There are flints whose alterations form effervescent marles. These do not appear to me to be of the nature of primitive rocks: they have the same origin as the calcareous stones, from which they differ only in consequence of a very considerable proportion of clay. The stones which we so abundantly find of this nature around us, among calcareous decompositions, may be considered as of this kind.

Water filtrating through mountains of primitive rock, frequently carries along with it very minutely divided particles of quartz; and proceeds to form, by deposition, stalactites, agates, rock crystal, &c.

These quartzose stalactites, differently coloured, are of a formation considerably analogous to that of calcareous alabasters; and we perceive no other difference between them than that of their constituent parts.

II. Thus far we have exhibited, in a few words, the principal changes, and various modifications, to which the primitive rocks have been subjected. We have not yet observed either germination or life; and the metals, sulphur, and bitumens, have not hitherto presented themselves to our observation. Their formation



tion appears to be posterior to the existence of this primitive globe; and the alterations and decompositions which now remain to be enquired into, appear to be produced by the class of living or organized beings.

On the one hand, we behold the numerous class of shell animals, which cause the stony mass of our globe to increase by their remains. The spoils of these creatures, long agitated and driven about by the waves, and more or less altered by collision, form those strata and banks of lime-stone, in which we very often perceive impressions of those shells to which they owe their origin.

On the other hand, we observe a numerous quantity of vegetables that grow and perish in the sea; and these plants likewise, deposited and heaped together by the currents, form strata, which are decomposed, lose their organization, and leave all the principles of the vegetable confounded with the earthy principle. It is to this source that the origin of pit-coal, and secondary schistus, is usually attributed; and this theory is established on the existence of the texture of decomposed vegetables very usually seen in schisti and coal, and likewise on the presence of shells and fish in most of these products.



It appears to me that the formation of pyrites ought to be attributed to the decomposition of vegetables: it exists in greater or less abundance in all schisti and coal. I have found a wooden shovel buried in the depositions of the river De Ceze, converted into jet and pyrites. The decomposition of animal substances may be added to this cause: and it appears to me to be a confirmation of these ideas, that we find many shells passed to the state of pyrites.

Not only the marine vegetables form considerable strata by their decomposition; but the remains of those which grow on the surface of the globe ought to be considered among the causes or agents which concur in producing changes upon that surface.

We shall separately consider how much is owing to each of these causes; and shall follow the effects of each, as if that cause alone were employed in modifying and altering our planet.

1. The calcareous mountains are constantly placed upon the surface of the primitive mountains; and though a few solitary observations present a contrary order, we ought to consider this inversion and derangement as produced by shocks which have changed the primitive disposition. I must observe also that the disorder is sometimes merely apparent; and that



Some naturalists of little information have described calcareous mountains as inclining beneath the granite, because this last pierces, as it were, through the envelope, rises to a greater height, and leaves at its feet, almost beneath it, the calcareous remains deposited at its base.

Sometimes even the lime-stone fills to a very great depth the crevices or clefts formed in the granite. I have seen in Gevaudan, towards Florac, a profound cavity in the granite filled with calcareous stone. This vein is known to possess a depth of more than one hundred and fifty toises, with a diameter of about two or three.

It likewise happens frequently enough that such waters as are loaded with the remains of the primitive granite, heap them together, and form secondary granites, which may exist above the calcareous stone.

These calcareous mountains are decomposed by the combined action of air and water; and the product of their decomposition sometimes forms chalk or marle.

The lightness of this earth renders it easy to be transported by water; and this fluid, which does not possess the property of holding it in solution, soon deposits it in the form of gurns, alabasters, stalactites, &c. Spars owe their formation



mation to no other cause. Their crystallization is posterior to the origin of calcareous mountains.

Waters wear down and carry away calcareous mountains with greater ease than the primitive mountains : their remains being very light, are rolled along, and more or less worn. The fragments of these rocks are sometimes connected by a gluten or cement of the same nature ; from which process calcareous grit and breccias arise. These calcareous remains formerly deposited themselves upon the quartzose sand ; and the union of primitive matter, and secondary products, gives rise to a rock of a mixed nature, which is common in our province.

2. The mountains of secondary schistus frequently exhibit to us a pure mixture of earthy principles, without the smallest vestige of bitumen. These rocks afford, by analysis, filex, alumine, magnesia, lime in the state of carbonate, and iron ; principles which are more or less united, and consequently accessible in various degrees to the action of such agents as destroy the rocks hitherto treated of.

These same principles, when disunited, and carried away by waters, give rise to a great part of the stones which we have comprised in the magnesian genus. The same elements, worn  
down



down by the waters, and deposited under circumstances proper to facilitate crystallization, form the schorls, tourmaline, garnets, &c.

We do not pretend by this to exclude and absolutely reject the system of such naturalists as attribute the formation of magnesian stones to the decomposition of the primitive rocks. But we think that this formation cannot be objected to for several of them, more especially such as contain magnesia in the greatest abundance.

It frequently happens that the secondary schists are interspersed with pyrites; and, in this case, the simple contact of air and water facilitates their decomposition. Sulphuric acid is thus formed, which combines with the various constituent principles of the stone; whence result the sulphates of iron, of magnesia, of alumine, and of lime, which effloresce at the surface, and remain confounded together. Schists of this nature are wrought in most places where alum works have been established; and the most laborious part of this undertaking consists in separating the sulphates of iron, of lime, and of magnesia from each other, which are mixed together. Sometimes the magnesia is so abundant that its sulphate predominates: I have seen mountains of schistus of this nature. The sulphate of lime being very sparingly soluble in



water, is carried away by that liquid, and deposited to form gypsum; while the other more soluble salts, remaining suspended, form vitriolic mineral waters.

The pyritous schists are frequently impregnated with bitumen, and the proportions constitute the various qualities of pit-coal.

It appears to me that we may lay it down as an incontestable principle, that the pyrites is abundant in proportion as the bituminous principle is more scarce. Hence it arises, that coals of a bad quality are the most sulphureous, and destroy metallic vessels by converting them into pyrites. The focus of volcanos appears to be formed by a schistus of this nature; and in the analyses of the stony matters which are ejected we find the same principles as those which constitute this schistus. We ought not therefore to be much surprised at finding scorals among volcanic products; and still less at observing that subterranean fires throw sulphuric salts, sulphur, and other analogous products, out of the entrails of the earth.

3. The remains of terrestrial vegetables exhibit a mixture of primitive earths more or less coloured by iron: we may therefore consider these as a matrix in which the seeds of all stony combinations are dispersed. The earthy principles



ciples assort themselves according to the laws of their affinities ; and form crystals of spar, of plaster, and even the rock crystals, according to all appearance : for we find ochreous earths in which these crystals are abundantly dispersed ; we see them formed almost under our eyes. I have frequently observed indurated ochres full of these crystals terminating in two pyramids.

The ochreous earths appear to me to deserve the greatest attention of naturalists. They constitute one of the most fertile means of action which nature employs ; and it is even in earths nearly similar to these that she elaborates the diamond, in the kingdoms of Golconda and Visapour. If it were allowable to indulge in a fiction purely poetical, we might affirm that the element of fire, so far from being lost by the dispersion of the combustible principles of vegetables, becomes purified to form this precious stone so eminently combustible ; that nature has been desirous of proving that the terms Destruction and Death are relative only to the imperfection of our senses ; and that she is never more fruitful than when we suppose her to be at the moment of extinction.

The spoils of animals, which live on the surface of the globe, are entitled to some consideration among the number of causes which we



assign to explain the various changes our planet is subjected to. We find bones in a state of considerable preservation in certain places; we can even frequently enough distinguish the species of the animals to which they have belonged. From indications of this sort it is that some writers have endeavoured to explain the disappearance of certain species; and to draw conclusions from thence, either that our planet is perceptibly cooled, or that a sensible change has taken place in the position of the axis of the earth. The phosphoric salts and phosphorus which have been found, in our time, in combination with lead, iron, &c. prove that, in proportion as the principles are disengaged by animal decomposition, they combine with other bodies, and form the nitric acid, the alkalis, and in general all the numerous kinds of nitrous salts.



## P A R T III.

## CONCERNING METALLIC SUBSTANCES.

## INTRODUCTION.

**M**ETALLIC substances are distinguished from all the other productions of our globe, by an absolute opacity, a much greater specific gravity than that of any other substance, and a degree of brilliancy peculiar to bodies of this class.

The multiplicity of uses to which metals are applied in the arts, and in medicine, as well as the place which they occupy in the natural history of our planet, render the study of them both interesting and necessary.

1. One of the distinctive characters of metals is their opacity. The most opaque stone, divided into very thin laminæ, becomes transparent; whereas the thinnest plate of metal preserves



the same opacity as the mass itself\*. This truly characteristic property has induced artists to employ metals to reflect the images of objects. A thin covering of tin and mercury fixed on the surface of a glass, forms a mirror or looking-glass; and well-polished steel constitutes the mirrors of telescopes†. The hardness of a metal contributes singularly to facilitate the reflection of objects, as it renders it capable of taking a very fine polish: but its colour must necessarily concur to render it perfect; for these tinges

\* Gold excepted; which, when beaten into leaf of about the two hundred and eighty thousandth part of an inch in thickness, transmits light of a beautiful green colour. It is highly probable that other metals would become transparent if they could be mechanically divided, or beaten out into laminæ of sufficient thinness, or if artists had sufficient motives to attempt it.

See Newton on Light and Colours, for the proofs on which he grounds his general inference—that all bodies are transparent when sufficiently divided. T.

† I do not find that steel has ever been in general use for reflecting telescopes, though it has doubtless been tried among the many experiments made for the improvement of these instruments. A kind of bell-metal, consisting of one third tin, and two-thirds copper, is commonly employed for this purpose: the addition of about a fiftieth part of arsenic singularly contributes to the closeness of its grain. On this subject consult the Treatise of Mr. Edwards, annexed to the Nautical Almanac for 1787. T.



cause it to absorb a greater or less quantity of the rays. The great defect of metallic mirrors is, that their surface becomes tarnished by the inevitable alteration which the action of the air and moisture must produce.

2. The relative weight is likewise a character by which we may distinguish a metallic substance. A cubic foot (French) of marble weighs 190 pounds (livres); a cubic foot of tin weighs 510; and a cubic foot of gold 1348.

The metals, in general, likewise possess the facility of being extended and flattened when struck, or subjected to a strong and gradual pressure; this property is known by the name of *Ductility*. All the metals do not possess this quality; but those which possess the metallic qualities most eminently, exhibit this likewise. We may distinguish three states of ductility relative to the manner in which it is modified by various known processes. 1. Ductility under the hammer. 2. Ductility through the plate of the wire-drawer. 3. Ductility between the laminating rollers.

Metals ductile under the hammer present themselves in the following order: Gold, Silver, Copper, Iron, Tin, and Lead.

Metals ductile through the wire-drawer's plate



form the following series: Gold, Iron, Copper, Silver, Tin, and Lead.—As, in the operation of wire-drawing, the metal is strongly drawn, to cause it to pass through holes of various diameters, and to reduce it into threads, the metals do not resist this prodigious extension but in proportion to their greater or less tenacity. Mr. De Fourcroy has therefore distinguished this ductility from the foregoing, by attributing it merely to the tenacity of the metals.

There are some metals which are not ductile either under the hammer or through the wire-drawer's plate, but become very considerably so when an equal and gradual pressure is applied. Zinc is of this nature. Mr. Sage has reduced it into very thin and very flexible leaves, by passing it between the laminating cylinders.

Heat assists the ductility of all metals, by separating their integrant parts, and forming spaces or interstices which permit the compressed molecules to flatten and extend themselves. This circumstance has induced artists to avail themselves of the assistance of heat in the working of metals. Without this precaution they would either become hard, or crack; because the particles, being too near each other, would be no longer capable of giving way under the hammer.



The ductility of metals permits us to fashion them as we think fit; and it is upon this admirable property that almost all the arts are founded which relate to the working of metals. Without this property, metallic bodies would consist either of shapeless masses, or large pieces of such figures as casting might produce. But we should be deprived of the number of various objects which the arts have successively afforded to supply our wants or luxuries.

Nature very seldom presents us with metals possessed of the degrees of perfection here enumerated. She has concealed them in the bowels of the earth, combined with various substances; which, by masking or changing the metallic properties, have left to the industry of man the laborious task of extracting them, clearing them of their original combinations, and giving them the valuable qualities which are peculiar to metals. The metals, thus buried and concealed, form ores. These ores usually exist in clefts or crevices of rocks, which are distinguished by the name of Veins. These veins are more or less inclined to the horizon; and the degrees of inclination have caused them to be distinguished by the names of direct, oblique, inclined, or level veins, according to the angle they make with the horizon. The part of the  
rock



rock which rests upon the superior part of the vein, is called the Roof: and that part upon which the vein itself rests, is called the Bed of the vein. These veins are of various breadths, and are accordingly distinguished by the names of Slips or Veins.

They possess a greater or less degree of continuity, according to which they are distinguished by the names of continued or broken veins; and when the ore is found in spherical parts or masses, from space to space, these masses are called Bellies or Stock-works: A vein which does not penetrate to a considerable depth in the earth, is called by us *Coureur de Gazon*.

The characters from which mineralogists pretend to assert the existence of an ore in the bowels of the earth, are all equivocal and suspicious. The savage aspect of a mountain, the nature of the plants which grow upon it, the exhalations which arise from the earth, all afford characters too doubtful for a reasonable man to risk his fortune upon such indications alone. The dipping wand, or divining rod, is the fruit of superstition and ignorance; and the ridicule which has been successively thrown upon this class of impostors, has diminished their number; at the same time that the numerous dupes of  
this



this class of men have rendered their successors more prudent.

The nature of the stones which compose a mountain is capable of furnishing some indications. We know, for example, that ores are seldom found in granite, and the other primitive mountains; we know likewise that mountains of too modern a formation contain them very rarely; and we find them only in secondary mountains, in which the schistus and ancient calcareous stone are void of all impressions of shells.

The presence of ponderous spar, forming a stratum or vein at the surface of the earth, has been considered by many mineralogists as a very good indication. It appears to me even that this stone is the same which Becher has spoken of in his works, under the name of Vitrifiable Earth, which he considered as a principle of metals; and that it has been very improperly taken for quartz by his readers.

The vitrifiable stone of Becher—"lapidis species quæ in igne fluit, et fluens vitrum exhibet,"—and elsewhere, "transparens enim nonnihil est, albus, et quasi argenteis foliis interspersus, ad ignem faciliè liquabilis,"—was considered by him as a certain indication of the presence of ores, as appears by the following passage:

"Sine



“ Sine quo lapide, nulla minera bona est, nec fertilitatem promittit ; adeò enim iste lapis mineris necessarius est, ut vel nudè, et sine ullo metallo, in montibus existens, infallibile signum futuri metalli sit ; quod, hoc signo freti, non sine magnis interdum sumptibus, quærunt minerarum indagatores ; hanc ergo sive terram sive lapidem, non sine pregnantibus causis, pro principio primo omnium metallorum, minerarum, et lapidum ac gemmarum, statuimus et agnoscimus ; certis freti experimentis, ut in sequentibus demonstrabimus, quibus evincere possumus præfatam terram actu in metallis et mineralibus omnibus, nec non lapidibus et gemmis, existere, eorumque mixtum ut basim et fundamentum ingredi ; unde ea hypostasim suam, oppositam, diaphaneitatem, et fluxum nanciscuntur . . . . . Hæc ergo terra non modò cum præsens adest infallibile signum affuturi metalli est, sed et absens idem signum existit, defuturi nempè metalli . . . . . defectus hujus terræ proxima et frequentissima causa steriliùm minerarum existit . . . . lapis de quo egimus, non modo ut matrix, sed ut ingrediens et principium.”

When we possess indications of the existence of an ore in any place, we may use the borer, to confirm or destroy these suspicions, at a small expence.



It frequently happens that the veins are naked or uncovered: the mixture of stones and metals forms a kind of cement which resists the destructive action of time longer than the rest of the mountain; and as these parts of rocks, connected by a metallic cement, present a stronger resistance to the action of waters, which incessantly corrode and diminish mountains, and carry away their parts into the sea, we frequently observe the veins projecting on the sides of mountains incruusted with some slight metallic impression altered by the lapse of time.

Before we proceed to treat of metallic works in the large way, it will be proper to explain the methods of judging of the nature and value of an ore, in order that the members of society may not rashly hazard their fortunes. The nature of an ore is judged from inspection. A slight acquaintance with this subject is sufficient to enable the observer to form an immediate judgment of the nature of an ore. The blow-pipe is an instrument by the assistance of which we may in a short space of time become acquainted likewise with the species of the ore. This knowledge forms the docimastic art, or docimasia. In order to make the assay of an ore, in general (for all ores do not require the same process, as we shall hereafter observe), small pieces  
of



of the mineral are examined. These are cleared from foreign and stony substances as much as possible. The pure mineral is then pounded, and a certain quantity weighed, which is torrefied in a vessel larger and less deep than a common crucible. By this means the sulphur or the arsenic in combination with the metal are dissipated; and by the loss of weight resulting from the calcination, a judgment is formed of the proportion of foreign volatile matter it contained.

This first operation shews the proportion and quantity of sulphur and arsenic which may be mixed with the metal. The sulphureous smell may easily be distinguished from the smell of garlic, which characterizes arsenic. These foreign substances mixed with the metal are called Mineralizers.

In order to obtain an accurate judgment of the weight of the mineralizer, the augmentation in weight which the metal has undergone in passing from its metallic state to that of oxide or calx, must be added to the loss occasioned by the calcination.

Two hundred grains of this roasted ore are then to be taken, and mixed with fluxes capable of fusing and reducing it. In this operation a crucible is made use of; and a sufficient degree  
of



of heat being applied, the metal is precipitated to the bottom of the crucible in a button, whose weight indicates the quantity of metal contained in the ore.

These fluxes must be varied according to the nature of the ores under examination. It is necessary that they should all contain the coaly principle, to disengage the oxigene with which these metals are impregnated by the calcination. But the nature of the flux must be varied according to the fusibility of the metal. The three following will answer all these purposes :

1. The fusible material called black flux is made with two parts of tartar, and one part of nitre, melted together. The coaly and alkaline residue is used to reduce the ores of lead, copper, antimony, &c.

2. Two hundred grains of calcined borax, one hundred grains of nitre, twenty grains of flaked lime, and one hundred grains of the ore intended to be assayed, form the flux of Scopoli, of which I have found the advantage in the assay of iron ores.

The vitreous flux of Mr. De Morveau, made with eight parts of pounded glass, one of borax, and half a part of powder of charcoal, may be employed for the same purpose.

3. Arse-



3. Arsenic and nitre, in equal parts, form likewise a very active flux.

The neutral arsenical salt has been used with success to fuse platina.

As soon as the existence of a mine, and its nature and riches, are ascertained, it is in the next place necessary to be assured of a sufficient abundance and continuity of water to answer the purposes of the works. It is likewise necessary to be assured of possessing a sufficient quantity of wood or charcoal; and, more especially, a good director must be procured: for, in my opinion, a poor mine well managed is preferable to a rich one ill conducted.

These preliminary circumstances being accomplished, the most simple and least expensive processes must be employed in extracting the mineral from the bowels of the earth. For this purpose, shafts or galleries must be dug, according to the position of the vein, and the nature of its situation.

When it is practicable to arrive at the side of the vein, and at a certain depth, by a horizontal gallery, the works become more simple and economical; the same opening serving to draw off the waters, and extract the ore. Galleries are then to be carried on to the right and left; and  
shafts



shafts sunk, which communicate with the open air, as likewise others carried down into the vein. Galleries are likewise constructed, one above the other, and the communication of the works kept up by ladders. When the soil is friable, and defective in solidity, care must be taken to support it with timbers of sufficient strength, to prevent its falling in.

Pickaxes, wedges, and levers are used to detach the ore, when the rock is soft; but it is most commonly necessary to employ gunpowder, and to form mines.

Want of air, and the abundance of water, are almost always noxious, and derange mine-works. The water is carried off by fire-engines, wind-mill pumps, and other suitable apparatus.

Currents of air are produced by establishing communications with the galleries by horizontal apertures. Furnaces erected on the side of a shaft, to which a long tube is adapted at one end, communicating with the ash-hole, and at the other plunging into the shaft to draw up the air, or ventilators placed in the same situation, answer a similar purpose. The foul air is destroyed by rendering a lixivium of ashes caustic; and sprinkling quick-lime about the mine likewise produces the same effect.



A prudent company ought to extract the largest possible quantity of ore, before they determine upon constructing the necessary works for the subsequent processes. We cannot see into the bowels of the earth. Appearances are often deceitful; and we have seen companies either ruined or discouraged, because they had employed immense sums to construct the necessary furnaces to work an ore whose existence was doubtful. When the proceedings, in an undertaking of this kind, are carried on with proper precaution, and no more expence is entered into than what the ore extracted, and of a known value, is capable of representing, the probable losses are very slight, even in the poorest mine.

The works ought to be varied according to the nature and state of the mineral. It is found in three states—1. In the form of a native metal: in this case, nothing more is necessary than to extract it out of the mine, to clear it of the extraneous substances, and to fuse it. 2. In the form of calx or oxide; and in this state it is sufficient if it be sorted and fused. 3. Combined with sulphur or arsenic, in which case it must be made to undergo some other operations.

Although, in this last case, the works, subsequent



quent to the extraction, vary according to the nature of the ore, there are nevertheless certain general operations to which every kind of ore is subjected, which we shall here speak of.

The metal is always mixed with stony substances, which are called the Gangue. The first business must therefore be to clear the metal of this foreign substance. For this purpose, when the ore is extracted, children are employed who examine it, and separate the pure ore or rich mineral from that which is mixed with the gangue. As in this second quality the stone is mixed with the ore, the whole is pulverized by means of a stamping mill, consisting of pestles of wood, shod with iron, and armed with cocks, which are raised by levers proceeding from the axis of a wheel that constantly turns. The mineral is by this means crushed and pulverized; and a stream of water which is made to pass over it, carries away both the metallic and stony particles; the former being deposited in the first vessels through which the water is made to circulate, while the latter or stony part is carried to a greater distance on account of its lightness.

This pulverized ore is called Sclich; and, in order to separate all the earthy parts, it is washed upon tables slightly inclined, over which a con-



stant stream of water is made to flow. The sclich is agitated with brooms; the water carries away all the fragments of stone, and leaves the pure ore upon the table.

The calcination of the mineral succeeds the washing. In this operation the mineralizer is carried off. Fire is always the agent made use of. Sometimes the pounded mineral is disposed in piles upon heaps of wood, which, being set on fire, heat the ore strongly, and drive off the mineralizer. This calcination possesses the double advantage of disposing the metal for fusion, as well as clearing it of the mineralizing substance. When the ore is more friable, it is spread out in a reverberatory furnace; and the flame which reverberates upon it deprives it of its mineralizer, at the same time that it partly fuses it.

Mr. Exchaquet has proposed to destroy the sulphur by nitre. This process is excellent for copper ores. The quantity of nitre varies according to the quantity of sulphur; but there is no danger of adding too much. In this operation the mixture is thrown into an ignited crucible, and kept at a moderate heat for some minutes.

The fusion is effected in furnaces, excited by a current of air, kept up by means of large bellows, or a machine called a *trompe*.

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The *trompe*, or blowing-machine\*, is formed of a hollow tree which rests upon a cask whose lower head is knocked out, and the open part of the cask itself plunged to a certain depth under water. A current of water is made to fall through this wooden trunk upon a stone which is erected in the middle of the cask. The air becomes disengaged, and is obliged to pass out at a collateral aperture in the cask, by means of a tube which carries it to the lower part of the furnace. This air is afforded—1. By that air which the water carries along with it. 2. By a current which passes through apertures made at the distance of six feet from the summit of the tree, and called *trompilles*.

The dimensions of a good *trompe* are the following :

Length of the tree or wooden trunk, from its summit to the side apertures or *trompilles*, six feet.

Length of the tree from the *trompilles* to the cask, eighteen feet.

Height of the cask, five feet.

Diameter of the cask, four feet six inches.

\* I do not find in Lewis's Commerce of Arts, where this subject is well treated, that the English have called this machine by any appropriated name. T.



The form of the internal part of the trunk, above the trompilles, is that of a funnel, whose superior opening is eighteen inches, and its inferior diameter five.

The diameter of the cavity of the tree, below the trompilles, is eighteen inches.

The diameter of the trompilles is six inches.

The stone upon which the water falls is eighteen inches in diameter.

When the mineral is once cleared of its gangue, its mineralizer, and all other foreign matter, it constitutes what is called a metal, or *régulus*.

Every fact appears to prove that metals are simple substances; the various alterations to which they are subjected, being combinations of the metal itself with other substances. None of these operations either disengage or separate any constituent part of the metal itself, as we shall see.

Every metal is fused at a certain degree of heat, more or less intense; and in this situation their surface is convex.

Messrs. Macquer and Lavoisier having exposed gold to the focus of the lens of Tschirnhausen, observed that this metal exhaled in fumes, without being decomposed; as was proved by collecting it unaltered upon presenting  
ing



ing a plate of silver, which became gilt. Silver is volatilized in the same manner without decomposition.

Metals fused, and cooled slowly, exhibit crystallizations of considerable regularity. The abbé Mongez, and Mr. Brogniart, have succeeded in crystallizing most of them, by varying the process used by the celebrated Rouelle in the crystallization of sulphur.

Most metals kept in a state of fusion lose their metallic brilliancy, and become converted into an opaque powder called Oxide, or Metallic Calx. The oxides, when urged by a stronger heat, are reduced into a vitriform substance, known by the name of Metallic Glass.

Metals acquire weight in their transition to the state of oxide. This circumstance has led several adepts into error, who imagined they had increased the weight of the metal.

Geber observes, "*Ubi vel minimum augmenti metallici inveneris, ibi te dicimus esse ante fores philosophorum.*"—"Et sane conveniens judicium est," adds Becher; "*id enim per quod corpus homogeneum augmentum capit, id ipsum est quod pro principio istius corporis haberi potest.*"—*Phys. Subt.*

Stahl pretended that the calcination of metals arose from the disengagement of phlogiston;



and he considered their calces as an earth, or metallic basis.

Boyle affirmed that the increase of weight in calcined metals was owing to the combination of the matter of fire : and Boerhaave ventured to attribute it to the surrounding bodies, which deposited themselves upon the metal. Of all the hypotheses which have been formed upon this subject, that of Stahl has met with the greatest number of supporters : and the blind zeal of his followers has carried them so far as even to disguise an unanswerable objection ; namely, that it can never be explained how metals, by the loss of one principle, at the same time that they do not acquire another, can become heavier. The reduction of the oxides or metallic calces, without any addition of charcoal, cannot be explained on this hypothesis.

It must be confessed that all chemists were not of this way of thinking : and we find in the writings of Jean Rey, a physician of Perigord, that he in the year 1630 attributed the increase of weight in calcined metals to the combination of air with the metal. He affirms that agitation facilitates this combination in no other manner than water renders the sand heavy which is thrown and agitated in that fluid.

He reasons like a chemist of considerable skill,



skill, to prove that the increase of weight cannot be carried beyond a point of saturation; and he concludes his observations in these words: *Le travail a été mien; le profit en soit au lecteur, et à Dieu seul la gloire*—"Mine has been the labour; let the reader enjoy the advantage, and to God alone be the glory \*."

All these several sketches were never formed into a connected system; and this doctrine was even completely unknown, when Mr. Lavoisier proved to us that the calcination of metals was owing merely to the fixation of oxygenous gas, and their reduction to the disengagement of this gas, effected by simple heat, or by its combination with various bases in such instances wherein its adhesion to the metal is too strong to be overcome by mere heat. The proofs upon which this celebrated chemist has established his opinion, are the following facts.

1. Metals are not oxidized either in a vacuum, or in air which contains no part of oxygenous gas. The Count Morozzo, Priestley, Lavoisier, and Pictet appear to have oxidized lead,

\* This is the same Jean Rey, who, being under the necessity of contradicting his friend Libavius on the theory of the calcination of metals, exclaims—"O Truth, how dear art thou to me! since it is in thy power to make me enter into a contest with so dear a friend."



tin, and mercury in the carbonic acid. See the Memoir of Mr. Sennebier, *Journal de Physique*, Fevrier 1787.—But this pretended oxide is nothing but a metallic carbonate, or the combination of a metal with an acid, which is very far from calcination or oxidation.

2. Metals inclosed under a glass, and properly heated, are oxidized only by absorbing the oxygenous gas contained in the mass of air which is insulated; and when this absorption is ended, it is impossible to carry the oxidation any further.

3. Metals oxidized in an atmosphere of oxygenous gas absorb it to the last drop.

4. Such oxidized metals as are capable of being reduced in closed vessels, give out, on their return to the metallic state, the same quantity of oxygenous gas as they had before absorbed.

This doctrine appears to me to be established on the most complete series of proofs which can be desired in matters capable of demonstration.

The concurrence of air and of humidity singularly assists the alteration of metals. The water is decomposed in this process, and its hydrogen is dissipated, while its oxygen combines with the metal. This is doubtless the theory of such oxidations as are effected beneath  
the



the surface of water; and when we find oxides, or metallic calces, in the bowels of the earth, defended from the contact of air, the facts ought to be referred only to the decomposition of water, or of acids which have oxygen for their base.

Hence it follows that the alteration of metal will be the more speedy—1. In proportion as the affinity of the metal to oxygenous gas is stronger. 2. As the quantity of oxygenous gas is greater. 3. As the air is more humid, &c. Metals decompose certain substances in order to unite with their oxygen, and by that means to pass to the state of oxide. This is observable when the nitric acid is digested upon certain metals.

Metallic substances being considerably numerous, it is necessary to class them, that we may bring together such as possess similar properties, and separate others which differ from them.

Ductility serves as a leading character. Metals may be distinguished into such as are ductile, and such as do not possess this property. The name of Metal has been peculiarly applied to the former, and that of Semi-metal to the latter kind.

Among the metals there are some which are changeable by exposure to air, while others are  
not



not sensibly altered in the same situation. This difference has caused a subdivision of the metals into perfect and imperfect metals.

We shall begin by treating of the semi-metals, because for the most part they approach to the saline or stony substances in their qualities; and we shall conclude with the perfect metals, because they possess the metallic qualities in an higher degree.

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## C H A P. I.

### *Concerning Arsenic.*

**T**H E substance which is sold in commerce under the name of Arsenic, is a metallic oxide of a glittering whiteness, sometimes of a vitreous appearance; exciting an impression of an acrid taste on the tongue; volatile when exposed to fire, in which situation it rises in the form of a white fume, with a very evident smell of garlic.

Although arsenic is most commonly met with  
under



under this form, it may be reduced to the metallic state by treating it with oils, soaps, or charcoal in closed vessels. The celebrated Becher was perfectly acquainted with this process—"Si oleum, vel quodcunque pingue, arsenico misceas, et per retortam distilles urgenti igne, sublimabitur in collum arsenicum, insigniter antimonii instar metallizatum."—The arsenic which sublimes is of a brilliant grey colour, resembling steel, but it speedily becomes black in the air: it forms crystals, which Mr. De Lisle considers as aluminiform octahedrons.

Arsenic is sometimes found native; and it is met with in stalactites, or in protuberant depositions formed of layers more or less distinct and concentric, which are separable from each other like the coats of an onion, or the laminæ of shells, from which it has obtained the name of testaceous arsenic. In other instances the masses are formed of very small scales; which renders the surface of the specimen sometimes granulated, and sometimes full of small cavities: it is then called scaly arsenic. Arsenic is also found in friable masses, possessing scarcely any consistence. In these various forms we receive it from Bohemia, Hungary, Saxony, Saint Marie aux Mines, &c.

Arsenic is volatilized by an heat of about



144 degrees of Reaumur. In order to set fire to this metal, it must be thrown into a crucible strongly ignited; and then it exhibits a blue flame, and rises in the form of a white oxide.

If it be sublimed by a gentle heat, it crystallizes in trihedral pyramids or in octahedrons.

Arsenic is not soluble in water. Its specific gravity is 57,633, according to Briffon. Its fracture resembles that of steel, but it easily tarnishes.

Arsenic appears to exist in the metallic state in its combinations with cobalt in the testaceous cobalt ore, or with iron in mispickel, according to the observation of Bergmann.

Arsenic unites by fusion with most of the metals; but those which were ductile before this addition, become brittle afterwards. Those which are of difficult fusion alone flow more easily by heat with the addition of arsenic, and those which are very fusible become refractory by the same addition. The yellow or red metals become white with this alloy.

Arsenic is often combined with metals in various ores, and is disengaged from them by calcination. In various mine works, long winding chimneys are constructed, through which the arsenical vapours pass, and in which they attach themselves. The crust which is formed



in process of time against the internal surface of these chimneys is taken away, and is the substance met with in commerce under the name of arsenic. The cobalt ores of Saxony, which are torrefied to separate this semi-metal, afford almost the whole of what is sold. This oxide of arsenic is sometimes native, and has been found in Saxony and Bohemia. It is very abundant in such places as are situated in the vicinity of subterranean fires, such as the Solfatara. It is often found crystallized in octahedrons, according to Mr. Sage.

The oxide is less volatile than the metal itself; and, as we have before observed, it emits a very evident smell of garlic. If it be sublimed by a strong fire in closed vessels, it becomes transparent like glass; but its surface is soon rendered opaque again by exposure to air. It is not rare to find arsenical glass in the arsenic of commerce: it is yellowish, and soon loses its transparency by exposure to air. This glass is sometimes found native in the cobalt mines, and among volcanic products.

Eighty parts of distilled water, at the temperature of twelve degrees, are required to dissolve one part of the oxide of arsenic; but fifteen are sufficient at the boiling heat.

One part of arsenic is soluble in between seventy and eighty parts of alcohol at the boiling heat.

The



The oxide of arsenic partakes therefore of the properties of saline substances, and differs from the other metallic oxides—1. Because it is perfectly soluble in water. 2. Because the other metallic oxides are without smell, and fixed in the fire. 3. Because those oxides do not contract any union with metals.

On the other hand it resembles the metallic oxides—1. In becoming converted into a metallic glass by a strong heat. 2. In forming an opaque insoluble substance, possessing the metallic brilliancy when deprived of oxygen.

The oxide of arsenic is capable of combining with sulphur; and the result is either orpiment or realgar, according to the manner of operating.

Most chemists have a notion that the realgar contains more sulphur than the orpiment; and they have prescribed different proportions to form these two substances. But it has been proved by Mr. Bucquet, that this difference of colour arises only from the manner of applying the fire; nothing more being necessary to convert orpiment into realgar, than the exposing it to a strong heat: and with the same mixture we may at pleasure obtain either of these products, according to the manner of applying the heat.

Orpiment and realgar are found native in  
certain



certain places. Linnæus, Wallerius, Bergmann, and Cronstedt have described them.

Crytals of realgar are found in Solfatara near Naples, according to Ferber; in the mines of Nagyag in Transylvania (see Forster's Catalogue); in the mines of Felsobanya in Upper Hungary; in those of Joachimstal in Bohemia, and of Marienburg in Saxony.

Realgar is common in China; it is made into vases, pagods, and other ornamental works. The Indians make use of these vessels to procure a purgative medicine: for this purpose they leave vinegar or lemon juice for several hours in the vessel, and afterwards drink it.

Realgar is commonly found in the waters of volcanos. I have almost always observed it in compressed hexahedral prisms, terminating in two tetrahedral summits.

Orpiment is less scarce than the realgar. It almost always accompanies this substance; but the orpiment of commerce comes to us from various countries up the Levant, in irregular masses, solid or lamellated, and of a beautiful orange yellow. The Baron de Born informs us that it is met with, in polyhedral crystals, in a blueish clay near Newsol in Hungary.

Lime and the alkalis decompose these two



substances, and disengage the oxide of arsenic.

The acids and the alkalis exhibit interesting phenomena with arsenic.

The sulphuric acid, when boiled on the oxide of arsenic, attacks and dissolves it; but this oxide is precipitated by cooling. If the whole of the acid be dissipated by a strong heat, the arsenical acid remains behind.

The nitric acid, assisted by heat, dissolves the oxide of arsenic, and forms a deliquescent salt, of which we shall presently treat.

The muriatic acid attacks arsenic very feebly. Messrs. Bayen and Charlard found its action very weak whether heated or cooled.

In order to form the sublimed muriate of arsenic, or butter of arsenic, equal parts of orpiment and corrosive sublimate of mercury are mixed together. The mixture is distilled by a gentle heat; and the receiver is found to contain a blackish corrosive liquor, which forms the sublimed muriate of arsenic. Cinnabar comes over if the heat be increased, according to the observation of Mr. Sage.

If pure pot-ash be boiled on the oxide of arsenic, the alkali becomes brown, gradually thickens, and at last forms a hard brittle mass. This arsenical salt of Mr. Macquer is deliquescent.

It



It is soluble in water, which lets fall brown flocks. It is decomposed by fire, and the arsenic escapes. Acids deprive it of its alkali, &c.

Soda exhibits phenomena nearly similar with this oxide; and Mr. Macquer even affirms that he obtained this salt in crystals.

I have proved that ammoniac dissolves the oxide of arsenic by heat; and I have several times obtained crystals of arsenic by spontaneous evaporation. I am even of opinion that the alkali is decomposed in these circumstances, that the nitrogene is dissipated, while the hydrogen unites with the oxygen of the oxide, and forms water.

The oxide of arsenic hastens the vitrification of all the earths; but the glasses into which it enters as a component part, have the property of easily becoming tarnished.

Equal parts of nitre and oxide of arsenic, distilled in a retort, afford a very red and almost incoercible nitric acid. Stahl and Kunckel obtained it by a process nearly similar. Macquer having resumed this work, carefully examined the residue in the retort, and found that it was a salt soluble in water, capable of crystallizing in tetrahedral prisms terminated by four-sided pyramids, unalterable in the air, fusible by a moderate heat, but without becom-



ing alkalized. Mr. Macquer called it the neutral arsenical salt: he supposed that no acid could decompose it. But Mr. Pelletier proved that the sulphuric, when distilled with it, disengaged its acid.

The arseniate of soda differs little from the arseniate of pot-ash. Mr. Pelletier obtained this salt crystallized in hexahedral prisms, terminated by planes perpendicular to their axes.

By these several experiments, Mr. Macquer had shewn that arsenic answered the purpose of an acid in these combinations. There remained only one step therefore to be made, to prove that it was really metamorphosed into an acid in these several operations: and it is to the celebrated Scheele that we are indebted for this discovery. His capital experiments upon manganese naturally led him to it.

He has given us two processes to obtain this arsenical acid; the first by means of the oxygenated muriatic acid, and the other by the nitric acid. These acids are distilled from the oxide of arsenic: the muriatic acid abandons its oxygen to the oxide of arsenic, and resumes the characters of the ordinary muriatic acid. The nitric acid is itself decomposed; and one of its principles is dissipated, while the other is fixed, and combines with the arsenical oxide.

This



This acid is at present obtained by distilling six parts of nitric acid from one of oxide of arsenic.

Mr. Pelletier likewise proposes to decompose the nitrate of ammoniac by the oxide of arsenic. The residue in the retort is the arseniate of ammoniac, from which the alkali may be driven by a fire long kept up. The residue is a vitreous mass, strongly attracting humidity, and falling into deliquium. It is the pure arsenical acid.

Mr. Pelletier has likewise decomposed the neutral arsenical salt, by mixing it with half a part of oil of vitriol, and urging the fire to such a degree as to ignite the vessels. The residue at the bottom of the retort is a white mass, which attracts humidity, and is the arsenical acid. A white powder is observable, which is found to be the sulphate of pot-ash or of soda, accordingly as the arsenical salt has soda or pot-ash for its basis.

From the various processes made use of to form the arsenical acid, it is evident that this substance is nothing but the arsenical oxide, saturated with the oxigene which it takes from the various bodies digested upon it. The nitric acid, or the nitrates used for this purpose, are decomposed; the nitrous gas passes over very



abundantly, and the oxigene remains mixed and united with the oxide of arsenic.

This acid possesses the concrete form; but it attracts the humidity of the air, and becomes resolved into a fluid.

It is fixed in the fire; but if it be heated in contact with a coaly substance, it is decomposed, and the oxide exhales in the form of fumes. It is reduced into arsenic, according to Mr. Pelletier, by passing hydrogenous gas through it.

At the temperature of twelve degrees of the thermometer of Reaumur, this acid requires only two-thirds of its weight of water to dissolve it; whereas one part of the oxide of arsenic requires twenty-four of water to dissolve it at the same temperature.

This acid, when dissolved in water, may be again concentrated, and carried to the state of a transparent glass without any alteration; for it is not by this treatment deprived of its power of attracting humidity from the air.

When it is in this state of concentration, it acts strongly on the crucible, and dissolves the alumine, according to Mr. Berthollet's experiments.

The arsenical acid, saturated with ammoniac, and duly evaporated, forms a salt crystallized in rhomboides; which, when urged by heat,  
loses



loses its water of crystallization, next its alkali, and is resolved into a vitreous mass.

Barytes and magnesia appear likewise to have a stronger affinity with this acid than the alkalis, according to Bergmann. Lime decomposes the neutral salts with base of alkali, according to the experiments of the same chemist.

Arsenic is used by the dyers; it is likewise used as a flux in glass-houses, and in docimastic works; it also enters as a component part into some glazes. Orpiment and realgar are very much used by painters; but arsenic is one of those productions whose advantages are not sufficient to compensate for its bad effects. This metal, which is very abundant, and very frequently met with in mines, causes the destruction of a number of workmen who explore them: being very volatile, it forms a dust which affects and destroys the lungs; and the unhappy miners, after a languishing life of a few years, all perish, sooner or later. The property which it possesses of being soluble in water, multiplies and facilitates its destructive power; and it ought to be proscribed in commerce, by the strict law which prohibits the sale of poison to unknown persons. Arsenic is every day the instrument by which victims are sacrificed, either by the hand of wickedness or imprudence. It is often



mistaken for sugar ; and these mistakes are attended with the most dreadful consequences. Whenever there is the least reason to suspect its presence, the doubt may be cleared up by throwing a small quantity of the powder upon heated coals. The smell of garlic, and the white fumes, are indications of the presence of arsenic. The symptoms which characterize this poison are, a great constriction of the throat, the teeth set on edge, and the mouth strongly heated ; an involuntary spitting, with extreme pains in the stomach ; vomiting of glairous and bloody matter, with cold sweats and convulsions.

Mucilaginous drinks have been long ago given to persons poisoned by arsenic. Milk, fat oils, butter, &c. have been successively employed.—Mr. Navier has proposed a more direct counterpoison. He prescribes one dram (gros) of sulphure of pot-ash, or liver of sulphur, to be dissolved in a pint of water, which the patient is directed to drink at several draughts : the sulphur unites to the arsenic, and destroys its causticity and effect. When these first symptoms are dissipated, he advises the use of mineral sulphureous waters. He likewise approves of milk, but condemns the use of oils. Vinegar, which dissolves arsenic, has been likewise recommended by Mr. Sage.



## C H A P. II.

*Concerning Cobalt.*

**C**OBALT was employed by artists to give a blue colour to glass, long before it was supposed to contain a semi-metal. We are indebted to Brandt, a celebrated Swedish mineralogist, for the knowledge of its properties, and metallic character.

The specific gravity of fused cobalt is 78,119. See Brissón.

Cobalt is combined in the bowels of the earth with sulphur, arsenic, and other metallic substances,

1. The arsenical cobalt ore is of a grey colour more or less deep, dull in its fracture, and becoming black on exposure to the air, in consequence of an alteration in its arsenical part.

This ore of cobalt crystallizes in smooth cubes, and affects several varieties. I have a piece which has the form of tetrahedral pyramids, joined base to base. This species of cobalt sometimes affects a confused crystallization in dendrites, and is then called Knit-cobalt ore. Sometimes it is found in protuberances, stalactites, &c.

2. The



2. The fulphureous ore of cobalt resembles the grey silver ore in its texture: it contains iron and silver; and effloresces of a lilac colour mixed with a yellowish green.—Sage, *Annal. Chem.* t. ii.

Mr. De Lisle possesses specimens of this kind, which came from the mine of Batnaes at Riddarhyttan.

3. Cobalt is mineralized by sulphur and arsenic, in the mine of Tunaburg in Sudermania.

The crystallization of this species is a cube, striated on its six faces, and commonly truncated more or less deeply on its edges.

This ore contains, according to Mr. Sage, fifty-five pounds of arsenic, eight of sulphur, two of iron, and thirty-five of cobalt.

4. The ores of cobalt are sometimes in efflorescence; and the fulphureous ore forms by its decomposition the sulphate of cobalt.

The sulphure of cobalt, and the arsenical cobalt ore, pass to the state of oxide in their decomposition; and the surface becomes covered with a colour of peach flowers, more or less intense. It is sometimes coloured with an efflorescence in the figure of stars formed by radii applied to each other collaterally, and all tending to a common centre. This is an indistinct crystallization, in which Mr. De Lisle thinks he observed



served tetrahedral prisms terminated by dihedral summits. The flowers of cobalt are frequently a mere powder, more or less coloured. Those ores which are in a state of complete decomposition are called Soft or Earthy cobalt ores.

To assay an ore of cobalt, the first process is torrefaction. Two hundred grains are afterwards fused with an ounce and a half of black flux. Mr. Sage is confident that more metal is obtained by mixing the oxide of cobalt with two parts of white glass, and a small quantity of coal.

When cobalt is mixed with bismuth and iron, its oxide must be distilled with equal parts of the muriate of ammoniac, until the salt which sublimes in the neck of the retort has acquired a green tinge. Mr. Sage, who gives us this process, observes that seven or eight sublimations are sometimes necessary to deprive the cobalt of all the iron and bismuth which it contains.

Cobalt is of a light grey colour, compact and brittle. It is not easily fused, is not volatile, resists cupellation, and refuses to amalgamate with mercury.

The working of cobalt ores is very simple. It consists in roasting the ore in a reverberatory furnace terminating in a long chimney, into  
which



which the vapours are received. These vapours, or arsenical fumes, attach themselves to the sides, and form a crust which is cleared off by criminals, who are condemned to this work for crimes that by the law deserve death. The cobalt ores of Saxony afford all the arsenic of commerce. When the oxide of cobalt is cleared of arsenic, it is known by the name of Zaffer. The zaffer of commerce is mixed with three-fourths of sand. This oxide, fused with three parts of sand, and one of pot-ash, forms a blue glass, which, when pounded, sifted, and afterwards ground in mills, included in large casks, forms Smalt. In order to obtain the blue of various degrees of fineness, the smalt is agitated in casks filled with water, and pierced with three openings at different heights. The water of the upper cock carries out the lightest blue, which is called Azure of the First Fire: the heavier particles fall more speedily; and the azure brought out by the water of the three cocks, forms the different degrees of fineness known under the names of Azure of the First, Second, and Third Fire.

Bohemia and Saxony have hitherto possessed the exclusive power of supplying us with these products. A description of these capital works may be seen in the mineralogical productions of  
Messrs,



Messrs. Jars. The works of Saxony have been supplied, for several years, by the cobalt ore discovered in the Pyrenean Mountains, in the valley of Gisten. But the Comte de Beust has formed establishments which secure to us the benefit of this commerce; and he has even been so fortunate as to find, near the village of Juget, a quartz sufficiently charged with cobalt to admit of being fused without any addition of colouring matter.

The establishment of the Comte de Beust is capable of manufacturing six thousand quintals of azure, or enamel blue; and is able not only to supply our own wants, but to enter into competition with the works of Saxony for the foreign trade\*.

He has likewise, in concert with the Baron Dietrich, discovered the process of making powder blue; a secret which was exclusively in the possession of the Hollanders till the present time.

Smalts are used in the preparation of cloths, laces, linens, muslins, thread, &c.

The azures are mixed with starch, and form the blue so well known and universally used by laundresses.

\* A description of the works of the Comte de Beust may be seen in the *Description des Gîtes des Minerais, des Forges, et des Salins des Pyrénées, par M. le Baron de Dietrich.*



It is likewise employed in forming blue paintings on fayence, porcelain, and other potteries; crystals and glasses are coloured blue by this substance; and it is also used in painting in fresco.

The coarsest blues are used by the confectioners and others, in the way of ornament; and in Germany they are used as sand for writing-paper.

The consumption of smalt, azure, blue sands, and zaffers, in the kingdom of France only, is estimated at four thousand quintals, which are sold from seventy-two to six hundred livres the quintal.

Cobalt is soluble in the acids.

One part of this metal, distilled with four parts of sulphuric acid, affords the sulphureous acid; and the residue in the retort is the sulphate of cobalt, soluble in water, and capable of crystallizing in tetrahedral rhomboidal crystals, terminating in a dihedral summit.

Barytes, magnesia, lime, and alkalis decompose this salt, and precipitate the cobalt in the form of oxide.

One hundred grains of cobalt dissolved in the sulphuric acid, and precipitated by soda, afford one hundred and forty grains of precipitate,  
and



and one hundred and fixty when precipitated by chalk.

The nitric acid diffolves cobalt with effervescence. The solution affords crystals in needles, which have not been strictly examined. This salt is deliquescent, boils on the coals without detonating, and leaves a deep red calx. I have seen this salt in very short beautiful hexahedral pyramids. It decrepitates and fuses on charcoal.

The muriatic acid does not diffolve cobalt in the cold, but by the assistance of heat it dissolves a portion of it. This acid acts more effectually upon the zaffer, and the solution is of a very fine green, and when diluted with water constitutes a very singular sympathetic ink; for it passes from a lilac, or violet colour, to purple, green, and black.

The nitro-muriatic acid likewise dissolves cobalt, and forms the sympathetic ink, which Helot has called the Ink of Bismuth.

Ammoniac likewise dissolves zaffer, and produces a liquor of a beautiful red colour.



## C H A P. III.

*Concerning Nickel.*

**H**YERNE appears to have been the first who treated of nickel, under the name of Kupfernickel, in 1694, in a work on minerals.

Henckel considered it as a species of cobalt or arsenic mixed with copper.

Cramer has likewise placed it among the ores of copper; and it was not until the year 1751 that Cronstedt obtained a new semi-metal from this pretended mixture.

Kupfernickel is found not only in the German districts, but likewise in Dauphiny, and in the Pyrenean Mountains. In digging out a calcareous stone for building, at Bareges, and opposite St. Sauveur, small veins and lumps of nickel were found in the calcareous spar, some parts of which were reduced to the state of green oxide. Mr. Sage, who analysed that of Biber in Hesse, and that of Allemont, found it to contain gold.



In order to obtain nickel from its ore, it must first be torrefied to disengage the arsenic; and the oxide must then be fused with three parts of black flux, and a small quantity of coal. This metal is of a reddish grey colour.

The specific gravity of fused nickel is 7,8070. Briffon.

As it is very difficult to drive off all the arsenic by a previous torrefaction, the metal, when urged by a violent fire, still suffers arsenic to escape.

The methods pointed out by Bergmann and Arvidson to purify nickel, consist in repeated calcinations and reductions: but these operations separate the arsenic only; and Bergmann admits that he did not succeed in completely depriving it of its iron, though he treated it by every suitable method. He seems disposed to consider it as a modification of iron.

The Dissertation of Bergmann De Nicolo, Opuscula, t. ii. may be consulted on the nature of this metal; and also the *Analyse Chimique* of Mr. Sage.

The sulphuric acid distilled upon nickel affords sulphureous acid, and leaves a greyish residue, which, when dissolved in water, communicates to it a green colour.

The sulphate of nickel effloresces in the air.



Nickel is attacked very strongly by the nitric acid. The solution, when evaporated, affords crystals of a beautiful green, in rhomboidal cubes.

The nitric acid likewise dissolves the oxide of nickel, and forms with it deliquescent crystals of a fine emerald green, and of a rhomboidal form, according to Bergmann.

The muriatic acid dissolves nickel, when heated. The solution produces crystals of the most beautiful emerald green, and of the figure of long rhomboidal octahedrons.

Cronstedt has taught us that nickel combines with sulphur by fusion, and that the result is a hard yellow mineral, with small brilliant facets. The same chemist dissolved this last metal in the sulphure of pot-ash, and formed a compound resembling the yellow copper ores.

Nickel does not amalgamate with mercury.



## C H A P. IV.

*Concerning Bismuth.*

**B**ISMUTH, or tin-glass, is a semi-metal of a shining yellowish white, disposed in plates and chatoyant. It has some analogy with lead; and, like that metal, it passes off on the cupel, carrying the baser metals along with it.

The specific gravity of fused bismuth is 9,8227.

—See Briffon.

Bismuth is the most easily fused of all the semi-metals, after tin. It requires only the 200th degree of heat.

It is found in various states in the bowels of the earth, either native, or combined with sulphur, arsenic, or oxigene.

1. Native bismuth is sometimes crystallized in cubes: Wallerius and Cronstedt found it in this form in the mines of Schneeberg in Saxony. These crystals often re-unite in the form of dendrites, in the spathose or quartzose gangues. Native bismuth is found in masses, covered with protuberances resembling stalactites.



Native bismuth is frequently altered by a slight decomposition of its metallic surface.

The native bismuth of Saxony is sometimes irised, and mixed with arsenic: it has a reddish jasper for its gangue.

2. Arsenical bismuth is of a whitish and brilliant grey colour. This ore is sometimes covered with an ochre of bismuth, and often contains cobalt. I have seen pieces of arsenical bismuth, from Schneeberg, in the form of dendrites on a gangue of jasper.

3. We are indebted to Mr. Cronstedt for the knowledge of a sulphureous ore of bismuth. That which he has described is of a blueish brilliant grey colour.

This species frequently possesses the lamellated texture of the large plated galena, which has caused Linnæus, Wallerius, and others, to give it the name of Galena of Bismuth. It is found at Batneas, at Riddarrhitan in Westmanland. It decrepitates on heated coals, and requires to be pulverised, in order to torrefy it without loss.

The galena of bismuth is sometimes striated.

The sulphureous ore of bismuth is sometimes compact, of an obscure colour, sprinkled with small brilliant points. That of Schneeberg in Saxony is of this kind.



Mr. De la Peyrouse discovered, in 1773, on the mountains of Melles in Cominges, in the quarter called Les Raitz, an ore of bismuth, which resembles this small plated galena, and has no external difference, excepting that it is less heavy. This ore is mineralized by sulphur, in the proportion of thirty-five livres per quintal.

4. Cronstedt, Linnæus, Justi, and De Born, have spoken of a bismuth ore of a greenish yellow, found in Saxony, and in Sweden. Mr. Sage communicated to the Academy, on the 17th of August 1780, the analysis of an earthy, solid, yellowish green ore of bismuth. He obtained quartz in the proportion of one-third, some carbonic acid, thirty-six pounds of bismuth per quintal, and twenty-four grains of silver: he found neither copper nor iron. Besides this green ore, he analysed a yellow, solid, slightly brilliant, and sometimes semi-transparent ore, which afforded him nearly the same results, but nine pounds more of bismuth.

This oxide must be fused in the blast furnace.

The fusibility of bismuth renders the working of this ore very simple, and the apparatus may be varied in several ways. Nothing more is necessary than to throw the ore into the fire, and to make a cavity underneath to receive the semi-metal.



Bismuth, when heated to redness, burns with a blue flame, scarcely perceptible. Its oxide rises in the form of a yellowish fume, which, when condensed, forms the flowers of bismuth. Its weight is increased twelve per cent. in passing to the state of oxide.

Mr. Darcet has converted bismuth into a glass of a dull violet colour.

Bismuth may be substituted instead of lead, in the process of cupellation. Its vitrification is even more speedy.

The sulphuric acid, boiled on bismuth, suffers sulphureous acid to escape, and partly dissolves the semi-metal. The sulphate of bismuth does not crystallize, but is very deliquescent.

The nitric acid attacks bismuth, and is very speedily decomposed. Nitrous gas is disengaged, while the oxigene is fixed in combination with the metal. There is nevertheless a portion dissolved which is capable of forming a salt in rhomboidal, tetrahedral prisms, terminating in a tetrahedral pyramid with unequal faces. This nitre detonates weakly with reddish scintillations; and melts, swells up, and leaves an oxide of a greenish yellow colour.

This salt loses its transparency in the air, at the same time that its water of crystallization flies off.

The



The muriatic acid does not act on bismuth but in the course of a considerable time; and for this purpose it must be highly concentrated. The muriate of bismuth is of difficult crystallization, and strongly attracts the humidity of the air.

Water precipitates this semi-metal from all its solutions; and the precipitate, when well washed, is known by the name of Magistery of Bismuth, or white paint for the complexion. This white is used as a pigment for the skin; but strong or sulphureous vapours, and even the animal transpiration, convert it into metal, and alter its colours. The hair-dressers, when they are desirous of converting hair to a black colour, smear it with a pomatum prepared with the magistery of bismuth.

Bismuth is used by the pewterers to give hardness to the metallic composition of pewter.

Mr. Pott has published a dissertation, in which he affirms that physicians have made use of some preparations of this semi-metal: but it is proper that it should be prohibited, because it almost always retains a portion of arsenic, and itself partakes of the noxious properties of lead.

The white of bismuth is very much used as a paint for the complexion. Its various solutions form sympathetic inks, which are more or less



curious, on account of the facility with which this oxide is altered, and becomes black.

Schluter, in his *Treatise of the Fusion of Ores*, pretends that it may be used in making the azure blue glass. But it appears from his own account, that he made use of a bismuth ore very rich in cobalt. For he says, that a moderate fire causes this ore to suffer its bismuth to flow out, and that the residue is a grey and fixed earth, which may be employed to advantage in making the blue.

This semi-metal unites with all the metals; but very difficultly, in the way of fusion, with the other semi-metals, or the metallic oxides. Antimony, zinc, cobalt, and arsenic refuse this union.

Bismuth fused with gold, renders it eager, and communicates to it its own colour. It does not render silver so brittle as gold: it diminishes the red colour of copper, but is deprived of its own colour by uniting with lead; the two metals, in this case, forming an alloy of a dark grey colour. When bismuth is mixed in a small proportion with tin, it gives it a greater degree of brilliancy and hardness. It may be united with iron by a violent heat.

Bismuth amalgamates with mercury, and forms a fluid alloy; a circumstance which has induced



induced certain unprincipled druggists to mix it with that metal. The fraud may be known from the mercury being less fluid than before, and no other test is necessary than to dissolve the mixture in spirit of nitre; for the bismuth will be precipitated by the addition of water.

This property, however, of amalgamating completely with mercury, may cause it to be applied with advantage in the silvering of glasses, by an amalgam of tin, bismuth, and mercury. This is, perhaps, the circumstance which has obtained it the name of tin-glass.

The fusible alloy of Mr. Darcet is a mixture of eight parts of bismuth, five of lead, and three of tin. It melts in water at the seventy-third degree of Reaumur, and flows like mercury.

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## C H A P. V.

### *Concerning Antimony.*

**A**NTIMONY is a semi-metal which has singularly engaged the attention of alchemists. They considered it as the basis of their  
great



great work ; and it is described in their writings under the names of the Radical Principle of Metals, Sacred Lead, &c.

This semi-metal is famous for the disputes which were maintained concerning it, at the beginning of the sixteenth century. It was prohibited by a decree of parliament, at the solicitation of the faculty of Paris. Paumier, of Caen, a skilful physician and chemist, was degraded by the Faculty of Medicine, for having employed it in 1609.

This same proscribed metal was re-established in 1624 ; and at present affords the most powerful remedies possessed by the medical art.

Bazilius Valentinus, a zealous partisan of antimony, pleaded its cause with much warmth and enthusiasm, in a work entitled *Currus Triumphalis Antimonii* : and Lemery has written a large volume to decry the preparations of this semi-metal.

As this substance afforded employment for a long time to the alchemists, its study is rendered particularly difficult by the multiplicity of preparations, and the barbarous names which have been given to them, and to the variety of processes. But by confounding preparations of the same nature ; by bringing the analogous products together, rejecting at the same time the numerous list  
of



of barbarous names which have been bestowed on one and the same thing; and by reducing the processes to that simplicity of which the well-known preparations are susceptible; we may succeed in forming an accurate and precise idea of the nature and properties of this metal.

Antimony is found in the bowels of the earth, in four different states.

1. In the metallic form.
2. Combined with arsenic.
3. Mineralized with sulphur.
4. In the state of oxide.

1. Some authors pretend that antimony in the metallic state was discovered in the year 1748, by Ant. Swab, in the mine of Sahlburg, in Sweden. Swab affirms that it has the colour of silver, that its texture is formed of large brilliant plates, and that it easily amalgamates with mercury. Cronstedt, Wallerius, Linnæus, and Cartheuser do not hesitate to admit of native antimony; but Lehman, Justi, and Vogel deny its existence: and Mr. De Lisle thinks that this pretended regulus is nothing but the white arsenical ore of antimony. The abbé Mongez affirms that he has discovered native antimony at Allemont in Dauphiny. It is the same ore which Mr. Sage has described under the name of the Arsenical Ore of Antimony.

If



If this native antimony really exists, it is probably crystallized like the metal itself, which is known to us, and whose crystals are either octahedrons inserted one in the other, or cubes placed one upon each other flantwise.

2. The arsenical ore of antimony may be considered as a true regulus by those who, after Bergmann, do not admit of arsenic as a mineralizer: for the ore is then considered as an alloy of the two reguli.

This ore is as white as silver, and exhibits large facets like antimony. The specimen was sent from Allemont in Dauphiny, to Mr. Sage. Its gangue is quartz. Small fascies of the grey and red ores of antimony striated and radiated, and not containing arsenic, are sometimes found in the cavities of this stone.

The antimony and the arsenic exist in the metallic state in this ore. The arsenic adheres so strongly to the antimony that it cannot be disengaged by torrefaction. Mr. Sage combined the ore with sulphur, and obtained orpiment and realgar. This mineralogist has concluded, from his analyses, that the arsenic existed in the proportion of sixteen pounds in the hundred.

3. Antimony is usually mineralized by sulphur, in which combination it exhibits three or four very distinct varieties. It is sometimes  
crystal-



crystallized of a grey colour inclining to blue. The crystals are very frequently slender, oblong, hexahedral prisms, terminated by tetrahedral pyramids. The mines which are wrought in Auvergne afford us beautiful prisms, of the same geometrical form, but thicker than those of the antimony of Hungary. These last crystals soon become of an irised colour; but those of the mines of Auvergne are not so speedily changed. I possess a large specimen of antimony from the neighbourhood of Alais, which is entirely covered with crystals perfectly similar to those of Hungary. It frequently happens that these crystals are confused and indistinct, in which case the ore appears to be formed of very slender prisms applied sidewise to each other. That which is called plumose antimony does not differ from these varieties, excepting that its crystals are very slender and detached. They are usually of a blackish grey. This variety has been arranged among the ores of silver, because for the most part it contains that metal.

Ores of antimony have been found in several parts of France; but our province of Languedoc exhibits very curious specimens. We have them at Malbos in the county of Alais. This mineral has been wrought in the diocese of Uzes; but the want of consumption has prevented



vented the works from going on with spirit. Mr. De Genfanne has observed in Vivarais a large vein of ore of antimony in a stratum of pitcoal.

The decomposition of the sulphureous ore of antimony produces the red antimonial ore. The red ore more especially accompanies the specular antimony of Tuscany. Its surfaces appear to be corroded or rendered carious by decomposition; and when a piece is broken, it emits a powder which has the properties of kermes.

The decomposition of sulphureous antimony likewise produces the sulphate of antimony. Some varieties of these antimonial decompositions may likewise be seen in the *Analyse Chimique* of Mr. Sage.

Antimony is found in two states in the course of trade; namely, in the form of crude antimony, and in the metallic form.

Crude antimony is nothing else but the sulphureous ore of antimony cleared of its gangue. For this purpose the ore is put into pots pierced at the bottom, and disposed upon other pots buried in the earth. The uppermost pots which contain the mineral are then heated; the antimony becomes fused, and flows, together with its sulphur, into the lower vessels, while the gangue remains in the upper pots.



As the mixture of antimony and sulphur is very fusible, this process may be varied in a thousand ways. I have myself wrought an antimonial ore with the greatest œconomy, by fusing it in a furnace, over the arch of which I had disposed the ore broken into pieces of five or six pounds weight each. The heat was communicated to the whole mass by five openings in the arch or roof; and the antimony, as it melted, ran down on the outside of the furnace by means of channels cut in the convex part of the dome. This method afforded forty quintals of antimony in twenty-seven hours, by the consumption of between twenty and thirty quintals of combustible matter.

We are acquainted with two methods of depriving crude antimony of its sulphur. 1. The slow and gradual calcination of the ore, which affords a grey oxide, and this urged by a violent heat is converted into a reddish and partly transparent glass of antimony. It does not assume this transparency unless it has been perfectly fused. The glass of antimony is a violent corrosive, but is capable of being corrected by mixing or kneading it with yellow wax, and afterwards burning off the wax; or otherwise by triturating it with a volatile oil. This is the cerated antimony of Pringle, so much extolled in dysenteries. 2. Or

3

otherwise,



otherwise, the antimony may be deprived of its sulphur by projecting into an ignited crucible a mixture of eight parts of crude antimony, six of tartar, and three of nitre. By keeping this mixture for a certain time in fusion, the antimony is obtained in the metallic state.

In the large works antimony is torrefied in an oven resembling that of the bakers. Fifty pounds of dried wine lees or tartar are mixed with a hundred pounds of the oxide of antimony, and the mixture is then fused in proper crucibles. The metallic button contains the form of the crucible; and these loaves of antimony exhibit a star on their upper surface, which has been considered as peculiarly characteristic; but is in fact nothing more than a confused crystallization formed by octahedrons inserted one in the other.

Copper, silver, and iron, when fused with the sulphure of antimony, seize its sulphur, and reduce it to the state of regulus. This has been distinguished by the name of the metal employed. Thus we hear of the regulus of Mars, of Venus, &c.

Antimony is difficult of fusion; but when once melted, it emits a white fume known by the name of Argentine Snow, or flowers of Antimony. These fumes, when collected, form very  
brilliant



brilliant prismatic tetrahedral crystals: Mr. Pelletier has obtained them in transparent octahedrons. The argentine flowers of antimony are soluble in water, which they render emetic. The volatility and solubility of this sublimed oxide exhibit a resemblance with the oxide of arsenic before treated of. We are indebted to Rouelle for these observations on the properties of this antimonial oxide.

Antimony is very slightly changed by exposure to air, in which it long preserves its brilliancy.

The specific gravity of fused antimony is 6,7021.—See Briffon.

The sulphuric acid, by slow ebullition upon this metal, is partly decomposed. Sulphureous gas first escapes, and sulphur itself is sublimed towards the end. When four parts of the acid are used with one of the antimony, the residue, after the action of the acid, consists of the metallic oxide, with a small quantity of the sulphate of antimony, which may be separated by means of distilled water. This sulphate is very deliquescent, and is easily decomposed in the fire.

The nitric acid is decomposed upon this semi-metal with great facility. It oxides a considerable part, and dissolves a portion, which may be suspended in water, and forms a very



deliquescent salt, decomposable by heat. The oxide prepared by this means is very white, and very difficult of reduction. It is a true bezoar mineral.

The muriatic acid acts upon antimony only by a long digestion. Mr. Fourcroy has observed that this acid, long digested upon the metal, dissolves it; and that the muriate of antimony, obtained by a strong evaporation in the form of small needles, is very deliquescent. It is fusible in the fire, and likewise volatile. Mr. Monnet has proved that twelve grains of the oxide of antimony are sufficient to saturate half an ounce of the ordinary muriatic acid. Messrs. Monnet and De Fourcroy have always found that there is a portion of the muriate of antimony which is not volatilized by the fire: this depends upon its being strongly oxidized or calcined.

If two parts of the corrosive muriate of mercury, and one of antimony, be distilled together, a very slight degree of heat drives over a butyraceous matter, which is called butter of antimony, or the sublimed muriate of antimony. It may be presumed that the acid in this composition is in the state of oxygenated muriatic acid, as it is in the corrosive sublimate.

The sublimed muriate of antimony becomes  
fluid



fluid by a very gentle heat; and by virtue of this property it may conveniently be poured from one vessel to another: for nothing more is necessary than to plunge the bottle which contains it into hot water, and the muriate may then be poured out in its liquid state.

I have several times observed this muriate of antimony crystallized in hexahedral prisms with dihedral summits: two sides of the prism are inclined, and form that which the ancient chemists distinguished by the name of crystals in the form of a tomb. This muriate is used as an escharotic. When the salt is diluted with water, a white powder falls down, called powder of algaroth, or mercurius vitæ. This powder does not contain an atom of the muriatic acid, and is merely an oxide of antimony produced by that acid.

Simple water has some action upon this semi-metal; for we find that it becomes purgative by remaining in contact with it. Wine, and the acetous acid, completely dissolve it: but the emetic wine is an uncertain remedy; because it is impossible to determine with absolute certainty the degree of its energy, which depends upon the very variable degree of acidity of the wine made use of. The emetic wine ought not therefore to be used but in external applications.



The gastric fluids likewise dissolve this ferri-metal, as is proved by the famous perpetual pills. This purgative has been distinguished by the name of Perpetual Pills; because, being very little alterable, the pill may be transmitted from generation to generation.

The acid of tartar forms a very well known salt with antimony, which is much employed in medicine, under the name of Emetic Tartar, Stibiated Tartar, or simply Emetic. It is this salt which, in the New Nomenclature, is distinguished by the name of Antimoniated Tartrite of Pot-ash.

In the examination of the various authors who have treated of the preparations of this remedy, as well as by comparing the most celebrated dispensatories, we do not find two which propose an uniform process which is constant and invariable in its effects.

Some prescribe the crocus metallorum, or semi-vitreous oxide of sulphurated antimony; others the glass of antimony; others the liver of antimony, or sulphurated oxide of antimony; and others the sublimed oxide: some combine several of these substances. But all in general adopt cream of tartar, or the acidulous tartrite of pot-ash, as a solvent.

The processes vary not only in the choice of



the substances to be made use of, but even in the proportions in which they are to be employed. We likewise find varieties in the quantity of water used as a vehicle, which is not an indifferent circumstance; in the time prescribed to digest the substances together, a circumstance of the greatest consequence to be ascertained, because the saturation of the acid depends absolutely and essentially upon it. The choice of vessels must likewise influence the effect of this remedy. Hoffman has affirmed that the emetic lost its effect by a long ebullition; and Mr. Baumé has proved that iron precipitates the antimony after a time, and consequently that the iron vessels prescribed in certain dispensatories ought to be rejected.

This variety in the processes must necessarily influence the result; and we cannot be much surprised that Geoffroy, who analysed several antimoniated tartrites of pot-ash, should have found from thirty grains to two gros and ten grains of metal in the ounce of this salt.

Is it not therefore of great consequence to prescribe a uniform process, whose product should be invariable? These heroic remedies, which operate in small doses, ought to produce constant and invariable effects through all Europe. It would be much more advantageous



that solemn proceedings should be made for the preparation of these active remedies, than for the composition of the theriaca, a true pharmaceutical monster, the dose of which may with impunity be varied from a few grains up to three hundred. It follows, from the variety of the effects of these sovereign remedies, that consultations become almost ineffectual; because the physician prescribes according to the effects of the remedies he is in the habit of using: and the art of medicine becomes no better than a discouraging alternative of success and disappointment.

At Montpellier, the emetic acts in a dose of one or two grains; but in other places it does not operate in a less dose than ten or twelve: and the stibiated tartar sold by those wholesale dealers in medicine, who supply the country apothecaries, is usually nothing but the sulphate of potash, or vitriolated tartar moistened with a solution of emetic. It is a thing greatly to be desired, that government, which does not apply its stamp of approbation to objects of luxury until they have passed a rigid inspection, should prohibit traders from circulating with impunity products upon which the health of the citizen so essentially depends. These are the frauds and deceptions which have engaged me to form an  
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establishment of chemical products, in which intelligence and probity preside over all its operations; and I have succeeded in my laboratories so far as to conduct the processes with sufficient œconomy to afford products faithfully made up, and invariable in their effects, at the same price as those sophisticated drugs with which the public has hitherto been poisoned.

The most accurate process for making an excellent emetic consists in taking very transparent glass of antimony, grinding it fine, and boiling it in water, with an equal weight of cream of tartar, until this salt is saturated. By filtration, and evaporation with a gentle heat, and subsequent repose, crystals of the antimoniated tartrate of pot-ash are obtained, whose degree of emeticity appears to be sufficiently constant. The crystals may be obtained in several successive products by repeated evaporations.

Macquer proposed the powder of algaroth, as more uniform in its power. Messrs. De Laffone and Durande have adopted the opinion of Macquer; and the celebrated Bergmann has followed the ideas of the French chemists, with a few slight modifications.

Take five ounces of cream of tartar reduced into powder, and two ounces two gros of the powder of algaroth precipitated by hot water,



washed and dried. Add water to these, and boil them gently. By filtration and evaporation the crystals of emetic tartar are obtained; which may be given in the dose of three grains, without fatiguing the stomach or intestines.

The antimoniated tartrate of pot-ash crystallizes in trihedral pyramids. It is very transparent, is decomposed on the fire with crackling, and leaves a coaly residue. Sixty parts of water dissolve it. It effloresces in the air, and becomes farinaceous. The solutions of this salt throw down a mucilage, which fixes, and forms a pellicle of considerable thickness: it is the mucilage of cream of tartar, which is insoluble in water, and partly soluble in alcohol. The sulphuric acid blackens it, but does not itself become coloured till after a long time. The nitric acid dissolves it partly; and is itself decomposed, with the emission of much nitrous gas.

The alkalis and lime decompose the antimoniated tartrate of pot-ash. Antimony, properly mixed with the nitrate, decomposes that salt completely. Equal parts of the semi-metal and nitre being thrown into an ignited crucible, the salt detonates, its acid is decomposed; and at the end of the operation the crucible is found to contain the alkali which served as the base of the nitrate, and the antimony reduced to the state  
of



of white oxide: this is called Diaphoretic Antimony. The same preparation may be made by using the sulphure of antimony; in which case three parts of the nitrate are used to one of the crude antimony. The residue in the crucible, after the detonation, is composed of the oxide of antimony, fixed alkali, a portion of the nitrate not decomposed, and a small quantity of sulphate of pot-ash. This compound is still known by the name of the Solvent of Rotrou. Water deprives it of all the salts it contains; and leaves only the oxide of antimony, which is called Washed Diaphoretic Antimony. If a small quantity of acid be poured on the fluid which holds the salts in solution, a small portion of the oxide of antimony falls down, which was dissolved by the alkali of the nitre. The precipitate forms the ceruse of antimony, or the pearly matter of Kerkringius.

Equal parts of the sulphure of antimony and of nitrate, detonated in an ignited crucible, form the liver of antimony, or sulphurated oxide of antimony; which, when pulverized and washed, produces the saffron of metals, or crocus metal-lorum.

The oxides of antimony have been considered as very difficult of reduction; and it was not without surprize that I at first observed the  
facility



facility with which they are all reducible by the black flux. This prejudice was established and propagated for want of proper experiments.

The alkalis do not sensibly act upon antimony: but the sulphures of alkali dissolve it completely; and it is upon this principle that an operation is founded by which we obtain a valuable remedy, known by the name of Kermes Mineral, to distinguish it from the vegetable kermes used in dyeing. The preparation is simply a red sulphurated oxide of antimony. This remedy, first pointed out by Glauber, who made it with antimony and the solution of nitre fixed by charcoal, is indebted for its celebrity to the wonderful cures it performed in the hands of Simon, a Chartreux friar; whence it obtained the name of the Powder of the Chartreux. This religious man obtained the composition from a surgeon named Laligerie, to whom it had been given by Mr. Chaftenay, lieutenant at Landau. Mr. Dodart, first physician to the king, bought the secret in the year 1720; and Mr. Laligerie rendered it public. According to his process, the pounded sulphure of antimony is boiled for two hours, with one fourth of its weight of the solution of fixed nitre or pot-ash, in twice its weight of very pure water. After ebullition the fluid is filtered; the kermes  
falls



falls down as it cools, and is afterwards dried. Laligerie directs that more of the solution of fixed nitre be digested on the metal, till it is completely dissolved. Laligerie burned spirit of wine or brandy upon it. The liquor which remains after the kermes is fallen down, contains more kermes, which may be disengaged by means of an acid. This kermes, which is paler than the former, is known by the name of Golden Sulphur of Antimony, or the orange-coloured sulphurated oxide of antimony.

This process is no longer used. That which succeeded the best with me, consists in boiling ten or twelve pounds of pure alkaline solution with two pounds of the sulphure of antimony. The ebullition is continued for half an hour, after which the fluid is filtered; and much kermes is obtained by mere cooling. I digest new alkali on the antimony, until it is consumed. The kermes which I obtain by this means is of a beautiful tufted appearance.

Geoffroy, who analysed the kermes in 1734 and 1735, found that one gros of kermes contained from sixteen to seventeen grains of antimony, from thirteen to fourteen grains of alkali, and from forty to forty-one of sulphur. But Messrs. Baumé, Deyeux, de la Rochefoucauld, and De Fourcroy, are not convinced that

the



the washed kermes contains an atom of alkali which is not necessary to its virtues.

Kermes is likewise one of those remedies in the preparation of which the greatest care ought to be taken. It is nevertheless a substance which all the apothecaries in the country buy at the fair of Beaucaire; and the analysis which I have several times made of this kermes, has convinced me that it very often is nothing else but pounded brick, mixed with vegetable kermes, and sprinkled with a strong solution of emetic tartar. I have found some which was merely a mixture of the fine brown red and the calx of antimony.

Lime and lime-water, digested upon pulverized antimony, afford, even in the cold, at the end of a certain time, a kind of kermes, or golden sulphur, of a beautiful red colour.

Antimony enters into the composition of printers types. It is likewise mixed with tin, to increase its hardness. It was formerly used as a purgative: for this purpose it was made into cups, in which water or wine was suffered to stand for a night, and taken by the patient the following day.

The sulphure of antimony is used as a sudorific in skin disorders. For this purpose it is tied in a cloth, and digested in the ptisans appropriated



propriated to these disorders. It is administered in pills for the same purpose.

The solvent of Rotrou has been much used to dissipate lymphatic concretions, and pituitous swellings.

Washed diaphoretic antimony is used in considerable doses to excite perspiration. Some physicians have considered it as a medicine void of effect; and Boerhaave has maintained that its effect is not more considerable than that of Lemnian earth.

The kermes mineral is one of the most valuable medicines that the healing art is acquainted with. It is incisive; and may be administered in all pituitous cases, when the stomach fails, and the lungs are obstructed. In a more considerable dose it is sudorific, and a still larger portion is emetic. It is employed in the dose of from half a grain to three.

The tartar emetic has received its name from its uses. It is dissolved in water; and this solution produces its effect.

The liver of antimony, crude antimony, and the crocus metallorum, are more especially used as purgatives in the veterinarian practice. They are given to horses in the dose of about an ounce.



## C H A P. VI.

*Concerning Zinc.*

**Z**INC is a metallic substance of a blueish brilliant white colour, very difficultly reducible into powder, but capable of being extended into very thin plates by the equal and gradual pressure of the flatting mill. From this last property, which has been proved by Mr. Sage, we may consider zinc as the intermediate substance between semi-metals and metals.

Zinc is found naturally in various states.

1. Cronstedt affirms that he saw a radiated crystallization of a metallic appearance, which is found at Schneeberg, where it is called flowers of bismuth, but which he found to be the regulus of zinc. This celebrated mineralogist does not venture to pronounce that it is native zinc.

Mr. Bomare affirms that he found it in small pieces in the mines of lapis calaminaris in the duchy of Limbourg, and in the zinc mines of Goslar. This regulus may have arisen from  
the



the scoriæ of furnaces, or from the ancient works; so that the existence of native zinc is still considered as very doubtful by these mineralogists.

2. Zinc is usually mineralized by sulphur, forming an ore known by the name of Blende, which in German signifies *blinding* or *deceitful*; a name which may have been given to it because such districts as abound with this mineral are barren of other ores.

The determinate crystallization of blende appears to be the alumini-form octahedron, and sometimes the tetrahedron; but the modifications of these primitive forms are so numerous, that the crystals are found in an astonishing variety of figures. Most commonly they are polyhedral crystals of an indeterminate form, or scarcely capable of being described. On this circumstance depend the denominations of Blende with Large or Small Plates, Striated Blende, Compact Blende, and other species, which may be seen in the works of Messrs. Sage, De Lisle, &c.

The colour of these blendes is infinitely various; they are found yellow, red, black, semi-transparent, &c.

All the blendes emit an hepatic smell when grated or triturated.

There



There is a kind of blende which exhibits a line of phosphoric flame when scratched with a knife, or even with a tooth-pick. Mr. De Bournon found this yellowish, transparent, and phosphoric blende, similar to that of Scharffenburg, at Maronne in the mountains of Oisan, at the distance of nine leagues from Grenoble. The phosphoric blende contains scarcely any iron.

To make the affay of a blende, Mr. Monnet advises solution of the ore in aqua fortis. The acid unites with the metal, and separates the sulphur: after which the oxide of zinc may be obtained by distilling off the acid; and this may be reduced. Bergmann obtains one part of the sulphur of these ores by distillation, dissolves the residue in acids, and precipitates the metal from its solutions. Mr. Sage distils blende with three parts of sulphuric acid: the sulphur sublimes by this operation; and the residue in the retort is the sulphate of zinc, mixed with a small quantity of sulphate of iron, and other substances mixed with the zinc. I do not know any country where blende is wrought to obtain the zinc: but it is sometimes mixed with lead; and in the working of this last metal the former is occasionally obtained. Such is the ore worked at Rammelsburg near Goslar, in the lower Hartz. Great part of the zinc is dissipated during the fusion



fusion of the lead ore ; but a portion of this metal is obtained by a very ingenious process. Care is taken to keep the anterior part of the furnace cool ; against which a stone is placed with a slight degree of inclination. The vapours of the zinc which are carried against this stone, are condensed, and fall in drops into powder of charcoal, with which a stone placed at the bottom is covered. The semi-metal is defended from oxidation by means of the charcoal ; and it is afterwards fused, and cast into convenient forms.

This zinc is always united with a small quantity of lead, and is less pure than that which comes to us from India, under the name of Tutenag.

I strongly calcined the blende of St. Sauveur, and mixed the powder with charcoal. I then put the whole into a retort whose orifice was plunged beneath water ; and by a violent heat, kept up for two hours, I obtained much zinc, which fell to the bottom of the water.

3. The decomposition of blende gives rise to the formation of the sulphate of zinc. The operation of nature is slow, but art has supplied its defect. All the sulphate of zinc which is met with in commerce, is prepared at Rammelsburg. For this purpose, after having roasted the galena mixed with the blende, it is thrown ignited into



cisterns full of water, where it is left for twenty-four hours. The roasted mineral is three times extinguished in the same water ; after which the lixivium is evaporated, and put into coolers. At the end of fifteen days, the water is decanted, in order to separate the crystals of the sulphate of zinc. These crystals are afterwards fused in iron vessels ; and the liquor is poured into coolers, where it is stirred till it congeals. We shall examine the properties of this salt in due course.

4. Zinc is likewise found in the state of oxide ; and it appears to me that nature makes use of two means of converting the metal to this state.

1. The sulphur is sometimes dissipated without the production of sulphate : in which case it is replaced by the oxygenous gas, and the result is that oxide of zinc which is known by the name of *Lapis Calaminaris*. I have found strata of *lapis calaminaris*, at St. Sauveur, intermixed with layers of blende ; and the transition of the blende to the state of *lapis calaminaris* may be followed in the most interesting manner. 2. The sulphate of zinc produced by the decomposition of blende in certain circumstances, is itself decomposed by calcareous stones. In the rich collections of Messrs. Sage, De Lisle, &c. we see crystals of calcareous spar converted into calamine at one end, and calcareous at the other.

Calamine



Calamine crystallizes in rhomboidal tetrahedral prisms, or in hexahedral pyramids.

It is sometimes covered with protuberances ; often has the appearance of being worm-eaten ; and is, at other times, either spongy or compact.

Its colour varies greatly. The county of Somerset affords it of white, green, and other colours.

To make a good analysis of calamine, Bergmann advises solution in the sulphuric acid ; he obtains the sulphates of iron and of zinc. That of iron is decomposed by a known weight of zinc ; and the metal is afterwards precipitated by the carbonate of soda. He has ascertained that ninety-three grains of this precipitate are equivalent to one hundred grains of zinc ; and from this weight he deducts that of the zinc made use of to precipitate the iron.

Zinc may be obtained from calamine by distillation. For this purpose I have used the same process as has already been mentioned in treating of blende.

Zinc yields beneath the hammer, without extending itself. If it be cast into small plates, it may then be laminated, and reduced into very thin and very flexible leaves.



The specific gravity of fused zinc is 7,1908.  
See Briffon.

Zinc, when heated, may be easily pulverized. This operation is very difficult without this precaution indicated by Macquer; for it wears and chokes up files, and destroys them in a short time; besides which, they have no considerable action upon it. It may likewise be fused and poured into water.—These are the most convenient means of pulverizing it.

Zinc, treated in close vessels, sublimes without decomposition: but, when it is calcined in the open air, it becomes covered with a grey powder, which is a true oxide; and, if it be heated to redness, it takes fire, emits a blue flame; and white flocks issue from it, which are called Philosophical Wool, Pompholix, or Nihil Album. This oxide may be fused into glass by an exceedingly violent heat: the glass is of a beautiful yellow colour. Zinc laminated into very thin leaves takes fire by the flame of a taper, and burns with a blue colour mixed with green.

Mr. De Laffone, who has written several excellent Memoirs on zinc, considers it as a kind of metallic phosphorus.

Water appears to have some action upon zinc.



zinc. When this semi-metal begins to be ignited, if water be poured on it, the fluid is decomposed, and much hydrogenous gas is disengaged. Messrs. Lavoisier and Meusnier have ascertained this fact, in their fine experiments on the decomposition of water.

Sulphuric acid dissolves it in the cold, and produces much hydrogenous gas. A salt may be obtained by evaporation, in tetrahedral prismatic crystals, terminated by a four-sided pyramid; Mr. Bucquet has observed that these prisms are rhomboidal. This salt is known by the name of Vitriol of Zinc, White Vitriol, Sulphate of Zinc: its taste is considerably styptic. It is not much altered by exposure to air when pure; but suffers its acid to escape, at a degree of heat less than is required by the sulphate of iron.

The nitric acid attacks zinc with vehemence, even when diluted with water. In this operation a great part of the acid is decomposed; but if the residue be concentrated by slow evaporation, crystals are obtained in compressed and striated tetrahedral prisms, terminated by pyramids with four sides. Mr. De Fourcroy, to whom we are indebted for this observation, adds, that the salt melts upon heated coals, and spreads abroad with decrepitation, and a small reddish flame. If it be exposed to heat in a



crucible, it emits red vapours, assumes the consistence of a jelly, and preserves this softness for a certain time. The nitrate of zinc is very deliquescent.

The muriatic acid attacks zinc with effervescence. Hydrogenous gas is produced, and black flocks are precipitated, which some chemists have taken for sulphur, others for iron, and which Mr. De Laffone considers as an irreducible oxide of zinc. This evaporated solution becomes thick, and refuses to crystallize. It suffers a very concentrated acid to escape when heated, and the muriate itself sublimes by distillation.

The pure alkalis boiled on zinc obtain a yellow colour, and dissolve a part of the metal, as Mr. De Laffone has proved. Ammoniac digested in the cold upon this semi-metal disengages hydrogenous gas: this evidently arises from the decomposition of the water, which alone, and without any mixture, is decomposed upon ignited zinc, as we have already observed.

Zinc mixed with the nitrate of pot-ash, and thrown into an ignited crucible, causes this salt to detonate strongly.

Zinc decomposes the muriate of ammoniac by simple trituration, according to Mr. Monnet.



Pott has observed that a solution of alum, boiled upon the filings of zinc, is decomposed, and affords the sulphate of zinc.

Zinc fused with antimony, forms a hard and brittle alloy.

It unites with tin and copper, and forms bronze; when combined with copper alone, it forms brass.

It is mixed with gunpowder, to produce the white and brilliant stars of artificial fire-works.

It has been proposed to substitute this metal in the room of tin, for the internal lining of copper vessels; and it is ascertained, from the labours of Mr. Malouin, that this covering would be more uniformly extended upon the copper, and would be harder than tin. It has been remarked that vegetable acids might dissolve it, and that these salts are dangerous; but Mr. De la Planche has made all the experiments on this subject which his extensive knowledge, and zeal for the public good, could inspire; and he is convinced that the salts of zinc, taken in a more considerable dose than the aliments prepared in vessels tinned with this semi-metal might contain, are not dangerous.

The sublimed oxide of zinc is much employed by the German physicians, under the name of Flowers of Zinc. This remedy is



given as an antispasmodic. It may be administered in pills, in the dose of one grain. Tutty, or pompholix, is mixed with fresh butter, as an excellent remedy in disorders of the eyes.

Mr. De Morveau has substituted the precipitate of zinc to white lead, with the greatest advantage. It perfectly answers the intention of the artist, and is not attended with any dangerous consequences in its use.

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## C H A P. VII.

### *Concerning Manganese.*

**A** MINERAL of a grey or blackish colour, foiling the fingers, and used in glass-houses under the name of Soap of the Glass-makers, has been long known in commerce. Most naturalists, such as Henckel, Cramer, Gellert, Cartheuser, and Wallerius, have placed it among the iron ores. Pott and Cronstedt did not consider it as a ferruginous substance. The latter found it to contain tin; and Mr. Sage



was long of opinion that it was an intimate alloy of zinc and cobalt.

The celebrated Bergmann, in the year 1764, declared in print, that black manganese ought to contain a peculiar metal; but he attempted in vain to extract it. However, Mr. Gahn, a physician at Stockholm, succeeded in obtaining a metal by the assistance of an exceedingly strong fire. We shall explain his process after having spoken of the different forms under which manganese is found in the earth.

Manganese appears to be always found in the state of oxide; but this oxide exhibits several varieties.

1. It is sometimes grey, brilliant, and crystallized, formed of very slender prisms confusedly intertwined, and resembling the ore of antimony; from which however it may be easily distinguished by exposing it upon charcoal. For antimony fuses, and affords vapours; but the manganese remains unchanged.

The crystals of manganese are striated, tetrahedral, rhomboidal prisms, terminating in four-sided pyramids. They frequently diverge from a centre.

2. Manganese is very often black and friable. This species is found in the cavities



ties of the brown hæmatites of the Pyrenean Mountains.

I have discovered an ore at St. Jean de Gardonenque, in the Cevennes. It is prodigiously light, is found in strata, and in pieces which almost always have the figure of an hexahedral prism, eighteen lines in length, and thirteen or fourteen in thickness.

This ore, upon which I have made experiments that I shall presently recite, is the purest and finest I am acquainted with.

3. Manganese is sometimes of a reddish white colour, and composed of groups of protuberances. Its fracture is lamellated. That of Piedmont frequently has a grey, reddish tinge, and appears to be composed of small plates. It gives fire with the steel.

The manganese of Macon in Burgundy is of a deeper grey than that of Piedmont.

That of Perigueux is intermixed with yellow martial ochre. It is found in separate bodies, and not in veins like that of Piedmont.

4. Most of the white spathose iron ores contain manganese, and may be considered as ores of this semi-metal. Manganese is likewise mixed with calcareous spar, gypsum, jasper, hæmatites, &c. Mr. De la Peyrouse has described  
thirteen



thirteen varieties of crystallized manganese found in the Pyrenean Mountains.—See the *Journal de Physique*, Jan. 1780, p. 67.

5. Scheele has proved that the ashes of vegetables contain manganese; and it is to this mineral that the colour of calcined pot-ash is owing. To extract it, three parts of fixed alkali, one of sifted ashes, and one-eighth of nitrate, must be fused together. The fluid mixture must then be poured into an iron mortar, where it congeals into a greenish mass. This being pounded, and boiled in pure water, must be filtered, and saturated with sulphuric acid. At the end of a certain time, a brown powder is deposited, which possesses the properties of manganese.

To reduce manganese to the metallic state, a crucible is lined with charcoal; and into a hole made in this charcoal, a ball of manganese, previously kneaded with oil and gum ammoniac, is to be put; after which the hole is to be covered with powder of charcoal. Another crucible must then be fitted on, and the vessels exposed to a violent fire for an hour and a half. By following this process, I have several times obtained the metal from the oxide of manganese of Cevennes. I have even succeeded in reducing



ducing it, by simply putting the powder of manganese into a lined crucible.

The button which is obtained almost always has asperities on its surface. Globules appear which scarcely adhere to the mass; and these portions are usually of a considerably deep green, while the internal part has a blueish cast.

This metal is more infusible than iron. I have several times observed, when the fire has not been sufficiently strong to fuse the manganese, that several globules of iron have appeared dispersed through the agglutinated oxide.

Saline fluxes ought to be rejected, as insufficient for this reduction. The great disposition which this semi-metal has to become vitrified, causes it to be dispersed in the flux, where it remains suspended. I have several times, by using the vitreous flux of Mr. De Morveau, obtained metallic grains forming a button, or else dispersed in the flux; which, when more narrowly examined, proved to be nothing but iron, cobalt, or other metals, according to the nature of the ore of manganese. I have sometimes obtained even globules of lead; because the coarsest glass in which the presence of that metal is the least suspected, and which enters into the composition of the flux of Mr. De Morveau, contains it very often.

The



The specific gravity of manganese has been estimated by Bergmann, in proportion to that of water, nearly as 6850 to 1000.

The oxide of manganese, when strongly heated in close vessels, affords a prodigious quantity of oxygenous gas, and begins to afford it at a degree of heat less than is necessary to disengage it from the oxides of mercury : a strong fire is required to disengage the last portions. Four ounces of the manganese of Cevennes afforded me nine pints of oxygenous gas. The residue in the retort was a grey oxide ; one part of which was incruited in the fused glass, and had communicated to it a very rich violet colour.

The oxide of manganese, distilled with charcoal, affords the carbonic acid : but, if it be calcined in an open vessel, it is reduced into a grey powder, which loses considerably of its weight when the fire is very strong ; and at length agglutinates, and forms a green mass.

If it be mixed with charcoal, it does not suffer any perceptible change in its colour.

Manganese, exposed to a very violent heat, vitrifies, and affords a glass of an obscure yellow colour. The iron which is mixed with it preserves its metallic form.

Manganese is easily changed in the air, and  
is



is resolved into a brown powder of a greater weight than the semi-metal itself: a certain proof of oxidation.

Manganese unites easily by fusion with all the metals except pure mercury. Copper alloyed with a certain quantity of manganese is still very malleable.

If a mixture of the phosphate of urine with a small quantity of oxide of manganese be placed upon charcoal, and be kept in fusion for a few instants by means of the blue interior flame of the blow-pipe, a transparent glass will be produced, of a blue colour inclining to red; which, when charged with a certain quantity of the salt, assumes the colour of a ruby. If it be kept in fusion for a longer time, a slight effervescence is perceived, and all the colour disappears. If the transparent globule be then softened by the exterior flame, the colour soon returns, and may be again effaced by keeping up the fusion for a time. The smallest portion of nitrate, added to the glass, immediately restores the red colour; and, on the contrary, it is destroyed by the addition of sulphuric salts. This globule of glass taken from the charcoal, and fused in the spoon of perfect metal, becomes red, and changes no more. These experiments were made by the celebrated Bergmann.

The



The sulphuric acid attacks manganese, and produces hydrogenous gas. This metal is dissolved more slowly than iron; a smell is disengaged similar to that which is afforded by the solution of iron by the muriatic acid. The solution is as colourless as water, and affords by evaporation transparent colourless crystals in the form of parallelopipeds, and of a bitter taste. Mr. Sage obtained them in tetrahedral prisms, terminated by four-sided pyramids. This salt effloresces in the air.

If the sulphuric acid be poured on the oxide of manganese, and its action assisted by a gentle heat, an astonishing quantity of oxygenous gas is disengaged. The oxide of manganese of Cevennes afforded me five pints and a half per ounce. When this oxide is deprived of its oxygen, the residue is a white powder, soluble in water, which by evaporation affords the sulphate of manganese, already described.

The celebrated Bergmann has observed that coaly matter, such as sugar, honey, and gum, assisted the action of the acid. This depends on the combination of the oxygen with these agents, to form the carbonic acid; and the sulphuric acid acts more easily upon the metal itself.

Manganese is precipitated from its solutions  
by



by the alkalis, in the form of a whitish gelatinous matter; but this precipitate soon loses its colour, and becomes black by the contact of the air. This phenomenon, which I have myself been a witness to, can be attributed, in my opinion, only to the absorption of oxygenous gas: and I was convinced of this truth by agitating the precipitate in bottles filled with this gas; for in this situation the black colour is produced in one or two minutes, and a considerable part of the gas is absorbed. I have constructed an eudiometer as certain and as invariable as that which the liquid sulphur of pot-ash, or solution of liver of sulphur, affords; but a large quantity of precipitate is required, which must be agitated against the sides of the vessels, in order that it may present a greater surface to the air, and that the absorption may be more speedy. I judge of the absorption by causing the vessel to communicate, by a graduated tube, with standing water. The ascension of this water in the tube is proportionate to the volume of oxygenous gas absorbed.

The nitric acid dissolves manganese with effervescence. There always remains a black, spongy, and friable body, which exhibited to Bergmann all the characters of molybdena. Other solvents presented a similar residue. The solu-



solution of the nitrate of manganese has frequently a dull colour, and assumes the red colour with difficulty. This solution does not afford solid crystals, even by slow evaporation.

The oxides of manganese are soluble in the nitric acid. It is observable that this acid is not decomposed upon them, because it finds the metal in the state of oxide. Carbonic acid is afforded when coaly substances are added to assist the solution. When the nitrous or fuming nitric acid is used, the solution is made without the assistance of these coaly substances, because the excess of nitrous gas seizes the oxygen of the oxide. These solutions do not crystallize.

The muriatic acid dissolves manganese; but when it is digested upon the oxide it seizes the oxygen, and passes in vapour through the water. This vapour is known by the name of Oxygenated Muriatic Acid, whose properties we have already explained.

The residue in the retort consists of a portion of acid combined with the manganese. This by evaporation affords a saline mass, which attracts the humidity of the air.

The fluoric acid with manganese affords a salt of sparing solubility, and this acid dissolves but little of it: but by decomposing the sulphate, the nitrate, or the muriate of manganese



by the fluat of ammoniac, a fluat of manganese is precipitated. The same phenomenon takes place with the phosphoric acid. The acetous acid has but a weak action upon this substance. If it be digested upon the oxide of manganese, it acquires the property of dissolving copper, and forms the beautiful acetate of copper, or crystals of Venus; whereas the same acid, digested on copper, forms verdigris, or simply corrodes it. This circumstance proves that the acetous acid becomes charged with oxygenous gas, by the assistance of which it dissolves the copper.

The oxalic acid not only dissolves manganese, but likewise the black oxide of manganese. The saturated solution deposits a white powder if there be not an excess of acid. This salt is blackened by the fire, but easily resumes the milky colour in the same acid. The oxalic acid precipitates it in the form of small crystalline grains, when poured into solutions made by the sulphuric, nitric, or muriatic acids.

The acidulous tartrate of pot-ash dissolves the black oxide, even in the cold. The tartrate of pot-ash added to any solution whatever of manganese, occasions a precipitate which is a true tartrate of manganese.

The carbonic acid attacks manganese and  
the



the black oxide. The solution becomes covered in the open air with a pellicle, which consists of manganese that is separated and oxidized. It is white when it does not contain iron.

If the muriate of ammoniac be distilled with this oxide of manganese, an elastic fluid is disengaged, according to the observation of Scheele, which he considers as one of the principles of ammoniac, without determining its nature. Mr. Berthollet has proved that, when ammoniac is disengaged by a metallic oxide, there is a portion decomposed. The oxigene of the oxide unites to the hydrogenous gas of the alkali to form water, and the nitrogene gas escapes.

Eight parts of oxidized manganese take up, by a gentle heat, in a glass retort, three parts of sulphur; and produce a mass of a greenish yellow colour, which acids attack with an effervescence and hepatic smell.

Manganese itself does not appear to combine with sulphur.

In order to separate iron from manganese, the alloy must be dissolved in the nitric acid, and evaporated to dryness. The residue must be strongly calcined, and digested with weak nitric acid, and a small quantity of sugar. The



acid takes up the manganese, which may be precipitated by the carbonate of pot-ash.

The alloy may likewise be put into a solution of the sulphate of iron. The acid abandons the iron to unite with the manganese.

The iron having less affinity with the acid than the manganese, may likewise be precipitated by a few drops of alkali.

The oxide of manganese is chiefly used in glass-houses, to deprive glass of its green or yellow colour, which soda and sand, when fused together, usually assume. It has on this account been called the Soap of the Glass-makers. It is also used to colour glass and porcelain of a violet colour.

The consumption of this mineral is become more considerable since the discovery of the oxygenated muriatic acid, which has pointed out its uses in bleaching of linen, cotton, &c.



## C H A P. VIII.

*Concerning Lead.*

**L**EAD is the softest, the least tenacious, the least sonorous, the least elastic, and one of the most ponderous, of metals. A cubic foot of lead weighs seven hundred and ninety-four pounds, ten ounces, four gros, forty-four grains. Its specific gravity is to that of water as 115523 to 10000, according to Brisson. Its fracture is of a blueish white colour, darker than that of tin, and tarnishing in the air. It possesses a peculiar smell, which is rendered perceptible by friction.

A gentle heat is sufficient to fuse lead; and the abbé Mongez obtained it in crystals of the form of quadrangular pyramids, recumbent on one side. Some authors affirm that lead is occasionally met with in the native state. Wallerius mentions three pieces of this kind. The German mineralogists likewise affirm that it has been found native in Villach in Carinthia. Mr. Genffane found in Vivarais, in four places,



at Serremejanes, at Fayet near Argentiere, at St. Etienne de Boulogne, and near Villeneuve de Berg, "grains of native lead, from the size  
 "of a chefnut to an almost imperceptible  
 "degree of smallness; they are all included  
 "in a very ponderous metallic earth, which is  
 "precisely of the colour of the ashes of beech,  
 "or of litharge reduced to an impalpable powder. This earth may be cut with a knife,  
 "but requires the hammer to break it." He found pieces which contained a substance similar to litharge in their internal part.

Linnaeus speaks likewise of a native lead in crystals.—Most naturalists agree to consider native lead as of a very problematical existence. The various samples found in cabinets are probably owing to ancient mine-works. Time has changed their appearance, and incruited them with various matters, which seem to prove that they do not owe their formation to the action of fire; and this is the circumstance which may have imposed on certain naturalists.

1. Lead is usually mineralized by sulphur; and this ore is known by the name of Galena.

It usually crystallizes in cubes, and in all the varieties of that figure.

Galena is distinguished into several species.

1. Large diced galena. 2. Small diced galena.



lena. 3. Scaly or plated galena. 4. Compact galena, in small brilliant grains resembling steel. It does not appear to be lamellated.

These distinctions are more especially necessary to be attended to, because the species are very different in richness, and the alloy of silver, which is inseparable from galena. In general, the large diced galena is poor in silver, and is used to give a glaze to pottery, by the name of *Alquifoux*, or potters lead ore. That which is in small grains is richer, and is wrought as a lead ore containing silver.

Galena is the only species of lead ore which is worked; and we shall relate all we have to say concerning the working and assay of lead ores after having spoken of the other ores.

2. Lead has been found mineralized by the sulphuric acid. Mr. Monnet has called this ore the pyritous lead ore. It is friable, dull, black, and almost always crystallized in very long needles, or in stalactites. It effloresces in the air, and affords a true sulphate of lead. This appears to be of the nature of galena: for as the sulphate is not developed but by the efflorescence of the ore, it may be concluded that the sulphuric acid does not exist in the virgin ore itself.

Lead mixed with iron is sometimes combined



with the sulphuric acid. A large quantity is found in the island of Anglesea. It cannot be reduced upon charcoal with the blow-pipe, but it fuses into a black glass.—Dr. Withering has indicated this ore.

3. The carbonic acid very often mineralizes lead, and exhibits some varieties which we shall proceed to describe.

A. The white lead ore.—This is almost always found in the cavities of decomposed galena, or in the veins of powdery stone containing galena. It is heavy, and frequently of a greasy colour; decrepitates in the fire; and is easily reduced by distillation, affording only water and the carbonic acid. Its form is almost always crystalline, but varies prodigiously. The primitive form appears to be a dodecahedron, with isosceles triangular planes.

I have seen crystals accurately of the form of an hexahedral prism sometimes terminated by a six-sided pyramid. The ores of St. Sauveur in the Cevennes have afforded us this variety; Mr. Sage possesses white lead ore of Geroldseck crystallized in cubes.

White lead as transparent as flint glass has been found in England and in Siberia.

The analysis of the white lead of Siberia afforded Mr. Macquart, per quintal, sixty-seven



seven parts lead, twenty-four carbonic acid, six oxigene, and three water.

B. Green lead ore.—This differs from the foregoing only in the modifications produced by the colouring principle, which is copper, according to Spielman; and iron, according to the greatest number of chemists. Its form is usually that of a truncated hexahedron; and this ore is not so easily reduced as the white ore.

C. The black ore of lead.—Lead may return to the state of galena by resuming the sulphur it had lost; and this regeneration is not rare. It is enough that any hepatic vapour should strike the ore to effect this conversion. The ores of Tschopau in Saxony, and those of Huelgoet in Lower Brittany, exhibit fine instances of this phenomenon.

The gradations or intermediate specimens of these different ores establish an infinite number of species, which the naturalist can never admit but as varieties. The transition of the white lead ore to the black ore exhibits gradations of colour which it would be very superfluous to describe.

In the year 1766, Mr. Lehmann described a new species of lead ore, called Red Lead. It was found in Siberia, in the environs of Catherineburg.



burg. Its crystals are grouped, and adherent to quartz, to copper ores, or iron; and sometimes to galena, with crystals of white and green lead. It is frequently crystallized in rhomboidal tetrahedral prisms, short, and truncated obliquely.

Mr. Sage has considered this lead ore as a variety of the preceding species, coloured by iron, of which Mr. Lehmann has proved the existence. The abbé Mongez thinks it is mineralized by the arsenical acid.

Mr. Macquart has given us the most valuable information respecting the red lead ore; and has proved by an accurate analysis that it contains, in the quintal, lead thirty-six, oxigene thirty-seven, iron twenty-five, and alumine two.

4. The phosphoric acid has likewise been found naturally combined with lead. This ore, discovered by Gahn, owes its green colour to iron. It does not effervesce with acids. In order to assay it, it must be dissolved in the nitric acid by the assistance of heat, and the lead may then be precipitated by the sulphuric acid. The supernatant liquor being decanted off, and evaporated to dryness, affords the phosphoric acid.

This ore melts by the blow-pipe, and affords an opaque globular mass without reduction. Its  
habitudes



habitudes with fluxes resemble those of lead and its oxides.

Mr. De la Metherie has informed us that Mr. \* \* \*, an English gentleman, by treating lead ores with the blow-pipe, had observed that there was one whose globule crystallized by cooling, after having been in perfect fusion; and that these ores were not reducible by the blow-pipe. He suspected they were mineralized by the phosphoric acid. Mr. De la Metherie and this gentleman took seven ounces of the green lead ore of Hoffsguard, near Fribourg in Brisgaw; which, when treated by the foregoing process, afforded them phosphoric acid. The phosphoric acid combined with minium afforded them a green compound.

The decomposition of the ores which we have described frequently affords the oxides of lead, or calciform ores.

These oxides at first afford a powder which, being carried along by waters, often mixes with argillaceous, calcareous, or quartzose earths.

These oxides vary more particularly in their colour, which assimilates them more or less perfectly to ceruse, massicot, or minium.

In order to make the assay of a galena, it must be pulverized and torrefied. The torrefied mineral,



neral, mixed with three parts of black flux, affords by fusion a metallic button, which indicates the proportions of the lead in the quintal of the ore.

Bergmann proposes to make the assay of sulphureous lead ores by the nitric acid, which dissolves the lead and not the sulphur. The solution is then to be precipitated by the carbonate of soda; and one hundred and thirty-two grains of the precipitate are equivalent to one hundred of the metal. If the ore contains silver, ammoniac is to be digested on the precipitate, from which it dissolves the oxide of silver.

The various operations to which lead ore is subjected to obtain the lead, are—1. It is sorted, to separate the rich or pure ore from the pulverized matter, and the gangue which contains no metal. 2. The ore is pulverized, and its gangue separated by washing. 3. The ore is roasted in a reverberatory furnace, with occasional agitation, that it may present all its surfaces to the air; and when the external part begins to assume the form of a paste, it is covered with charcoal, the mixture is stirred, and the heat increased. The lead then runs on all sides, and is collected at the bottom of the furnace, which is pierced, and permits the metal to flow  
into



into a receptacle properly defended by a lining of charcoal.

The scoriæ, which still retain much lead, are fused by a blast furnace: the lead is cast into pigs for sale.

To disengage the silver which the lead may contain, it is carried to the refining furnace; where, by the united energy of fire, and the wind of bellows directed upon the melted lead, the metal is converted into a yellow scaly oxide, called Litharge. This litharge is driven off in proportion as it forms; and the silver remains alone in the middle of the cupel. The colour causes a distinction of the litharge into litharge of gold, or litharge of silver. When the litharge is fused in contact with charcoal, it resumes its state of metal; and the lead is so much the better, in proportion as it has been deprived of the silver it contained. The smallest alloy of fine metal renders it brittle.

Lead is fusible by a gentle heat. If it be kept for some time in fusion, it becomes covered with a grey oxide; which, when exposed to a more violent heat, capable of keeping it ignited, assumes a deep yellow colour, in which state it is called Massicot. Massicot may be converted into the red oxide, or minium, by the following process. When the lead is converted  
into



into massicot, it is thrown out, and cooled by pouring water upon it; after which it is carried to the mill, and ground into very fine powder, which is washed in water. The particles of lead which could not be pulverized in the mill, remain in the vessel where the washing is performed.

This oxide of lead is spread out upon the hearth of the furnace in which it is calcined. Lines are drawn on its surface; and it is stirred from time to time, that it may not clot together; and the fire is kept up for forty-eight hours. When the minium is taken out of the furnace, it is put into large sieves of wood, and passed through very fine net work, or cloth of iron wire, placed over the casks which receive the minium. We are indebted to Messrs. Jars for this information, who have given very curious details respecting the manufactories of minium in the county of Derby.

Mr. Geoffroy was of opinion, that, in order to form minium, no greater heat was required than one hundred and twenty degrees of Reaumur's thermometer. But this heat is not adapted to works on a large scale; for in these the roof of the furnace is kept at a red heat. The lead increases in weight ten per cent. by the calcination.



All these oxides, urged by a stronger heat, are converted into a yellow glass, so very fusible, that it penetrates and destroys the best crucibles. It is used in glass-houses, on account of its fusibility, not only to assist the fusion, but likewise to render the glass softer, more ponderous, of a more unctuous feel, and more susceptible of being cut and polished. These are the reasons for which it is made a part of the composition of flint glass, and crystal glass.

The oxides of lead, distilled without addition, afford oxygenous gas by a violent heat.—Priestley obtained it from minium, part of which was converted into globules of metal.

When these oxides are fused with coaly matter, the metal becomes revived.

The sulphuric acid boiled upon lead affords much sulphureous acid; and an oxide is formed, which arises from a combination of the oxygen of the acid with the lead. A portion of the lead is nevertheless dissolved; for if a sufficient quantity of water be poured on the residue, a very caustic salt is obtained by evaporation, in tetrahedral prisms, soluble in eighteen times their weight of water. This sulphate is decomposed by fire, lime, the alkalis, &c.

Very hot sulphureous acid, poured into a leaden vessel, corrodes and destroys it instantly.

The



The concentrated nitric acid is readily decomposed upon lead, and converts it into a white oxide; but when the acid is weak it dissolves the metal, and forms crystals of an opake white, in the form of segments of a three-sided prism. I have specimens of the nitrate of lead in my laboratory, which possess the form of truncated hexahedral prisms; three of the sides being broader than the others, and exactly similar to those which Mr. De Fourcroy obtained by insensible evaporation.

This salt decrepitates in the fire, and is fused with a yellowish flame upon ignited coals. The oxide of lead becomes yellow, and is reduced into globules of metal. Sulphuric acid takes lead from the nitric acid.

The muriatic acid, assisted by heat, oxidizes lead, and dissolves a portion. This salt crystallizes in striated hexahedral prisms.

This muriate is slightly deliquescent. Lime and alkalis decompose it.

The same acid poured on litharge decomposes it instantly. Fifty or sixty degrees of heat are produced. The solution affords fine octahedral crystals, of an opake white colour, a styptic taste, and of very considerable weight.

This salt decrepitates on the coals; and when the fire is increased, its water of crystallization escapes,



escapes, and it becomes converted into a mass of a beautiful yellow colour.

Three parts of water, at fifteen degrees of temperature, dissolve one part; and boiling water more than its weight.

The pure alkalis precipitate it in the form of a magma, which occasions a kind of *miraculus mundi*.

The affinity of the muriatic acid with the oxide of lead is so strong, that it is capable of decomposing all its combinations. Minium or litharge decomposes the muriate of ammoniac. The same oxides, triturated with marine salt, separate the soda; and it is upon these facts that Mr. Turner and others have established manufactories for procuring soda by the decomposition of marine salt\*.

The muriates of lead, calcined or fused, afford a pigment of a beautiful yellow colour. The ma-

\* I do not hear that soda has been separated from common salt by a method sufficiently cheap for the purposes of commerce. It is universally understood that Mr. Turner's profits arise from the sale of the combination of muriatic acid with the lead, which forms the yellow pigment known in London by the name of Patent Yellow. It may be produced simply by the fusion of litharge and common salt; the alkali being volatilized, and driven off, if the fire be sufficiently intense. T.



nufactories of soda have afforded a very considerable quantity, which is substituted instead of the fine Naples yellow.

4. The acetous acid corrodes lead; and affords a white oxide, known by the name of white lead.

To prepare this colour, the lead is melted, and cast into plates about half a line in thickness, four or five inches wide, and two feet long. These are rolled up in a spiral form, in such a manner that the revolutions remain at the distance of half an inch from each other. They are then placed in pots, upon three points, which project from the inside at about one third of the height. Malt vinegar is poured into these pots to the height of the bottom of the lead, and they are buried in dung beneath sheds. A great number of these are disposed beside each other, and several strata are formed. Care is taken to cover each pot with a plate of lead and boards. At the expiration of a month or six weeks they are taken out, and the white lead is separated. This white calx is then ground in mills, and afterwards put into a vat, from which it is taken out to dry. The drying is performed in the shade, because the sun impairs the colour. For this purpose it is put into  
small



small conical earthen pots; and when sufficiently dry it is wrapped in paper, and distributed for sale.

Ceruse does not differ from white lead, excepting that a more or less considerable quantity of chalk is mixed with it.

All the oxides of lead are soluble in vinegar. The solution of the acetate of lead, duly concentrated, crystallizes in efflorescent tetrahedral prisms; and forms the salt of saturn, or sugar of lead.

Caustic alkalis dissolve the oxides of lead, and the metal may be precipitated by the addition of acids. When the alkaline solution is concentrated, the lead re-appears nearly in the metallic form, and the alkali is found to have acquired a faint and very peculiar taste.

The uses of lead in the arts are multifarious. It is used to make water pipes, boilers, coverings for the roofs of buildings, tea-chests, and other articles of package. It is rendered proper for these uses, either by laminating it, or by causing it to flow out upon a bed of sand well rammed and levelled, or upon the cloth called ticking.

It is likewise used to make bullets and small shot. The bullets are cast in moulds; but the small shot is made in the following manner:—



Lead is fused with a small quantity of arsenic, to render it more brittle; and when its temperature is such as to admit of a card being plunged in it without burning, it is poured into a kind of cullender, pierced at the bottom with many holes, and containing lighted charcoal: this cullender is held over water; and the lead assumes a round form as it enters this liquid.

Lead is used in the tinning of copper vessels. This is a pernicious fraud supported by custom, and tolerated by the want of vigilance in the police. It is the more dangerous from the circumstance that fats, oils, and vinegar corrode or dissolve lead, which by that means becomes mixed with the aliments.

Lead ore is likewise used to glaze pottery. For this purpose galena is pulverized, and mixed with water. The vessel intended to be glazed is dipped into this fluid, after having been exposed to a first baking. It accordingly becomes covered with the galena; which, when exposed to a violent heat, passes to the state of glass, and forms a covering of the glass of lead over the whole surface. This process is attended with the inconvenience of introducing a dangerous poison into our culinary vessels, whose effects on the health of individuals cannot but be sensibly felt.



Oxided lead enters into the composition of glasses, crystals, and enamels. It possesses the advantage of facilitating the fusion, and giving the glass an unctuous feel, and a degree of softness, which renders it capable of being cut and polished.

White lead and ceruse are used by painters. These oxides possess the singular advantage of not being perceptibly altered by their mixture with oil; and form, by their whiteness and body, a basis or receiver, which is very suitable for a variety of colours. The workmen who grind these colours are affected by them; and sooner or later become subject to the painters colic, *colica pictorum*.

Litharge is at present used to decompose sea salt; and the muriate of lead by fusion forms a superb yellow, very much employed in varnish colours.

8. Ceruse is likewise much used for drying up habitual moisture of the skin, and for slight burns. It is applied to the skin in the form of powder, and there is no remedy more speedy.

The salt of saturn, or sugar of lead, is almost entirely used by the callico printers.

The vinegar of saturn, or the vegeto-mineral water of Mr. Goulard, is a very proper astringent in the consequences or remains of venereal



disorders : it is likewise used to wash burns and ulcers, and to facilitate their cure.

This extract is likewise used to clarify liquors, and to deprive brandies of their colour ; an evil practice which has been common for some years at Sette, though prohibited under heavy penalties.—The wine merchants avail themselves of this composition but too often, or of litharge, to render their four wines sweet. This fraud was prodigiously common at Paris in the year 1750 ; and it was proved that, in the interval of three years, thirty thousand muids of vinegar had been thus sweetened, and sold for wine.

The oxides of lead are likewise used to harden oils, or to render them more drying. In this operation the oxigene of the oxide combines with the oil, and causes it to approach nearer to the nature of resins. There is likewise a solution of lead in oils, which serves as the basis of plasters.



## C H A P. IX.

*Concerning Tin.*

**T**IN is a metal of a white colour, intermediate between that of lead and silver. It is very flexible, and produces a crackling noise when bended. No other metal possesses this property except zinc, in which it is infinitely less marked.

This metal is very soft, and the lightest of any of the entire metals. The specific gravity of fused tin is 7,2914, according to Briffon.

A cubic foot of this metal weighs about five hundred and ten pounds. It is very ductile under the hammer; and its tenacity is such, that a wire of one tenth of an inch in diameter is capable of supporting forty-nine pounds eight ounces without breaking. Mr. De la Chenaye has crystallized tin after several repeated fusions; he obtained by this means an assemblage of prisms united together sideways.

Tin has been found in the metallic state in the bowels of the earth. Mr. Sage possesses a specimen



cimen from the mines in Cornwall, and Mr. De Lisle likewise has one in his collection. This tin, so far from exhibiting any trace of fusion, has the external appearance of molybdena: it is easily broken; but the detached pieces may be flattened by the hammer.

Tin ore is either white or coloured.

1. The white tin ore, which has been often confounded with tungsten, crystallizes in octahedrons. Its texture is lamellated, and it frequently includes portions of reddish tin ore. That of Cornwall afforded Mr. Sage sixty-four pounds of tin in the quintal.

2. The coloured tin ore does not differ from the preceding, excepting that it contains iron, and sometimes cobalt. This ore usually has the form of irregular polyhedrons.

These ores afford carbonic acid by distillation when exposed to fire in a crucible. They decrepitate, lose somewhat of their colour, and become one-tenth less heavy.

Bergmann found sulphureous tin ore among the minerals he received from Siberia. He affirms that this ore was of a golden colour externally, resembling aurum musivum; and internally it presented a mass of radiated, white, brilliant, brittle crystals, which assumed changeable colours on exposure to the air.



To assay a tin ore, nothing more is necessary than to fuse it in the midst of the coals. Calcination in the open fire dissipates much of the metal, according to the observation of Cramer.

In the working of tin ores, the mineral must be sorted very exactly; after which it is to be pulverized, and washed upon tables covered with cloth. By agitation with a wisp or broom, the gangue is suspended or carried away by the water, and the tin ore remains alone.

The furnace made use of in Saxony for the fusion of tin ore, is a variety of the blast-furnace, on the hearth of which is a groove to receive the melted metal, and convey it into a basin; whence it is taken to be cast in moulds of copper or of iron.

The tin ores of Cornwall are frequently mixed with copper, and arsenical pyrites. The quartz, which is its gangue, is very hard; and on this account the operation is begun by torrefaction of the ore before it is pulverized. After the ore is washed, a separation of the magnetical iron is effected by means of loadstones. The ore is usually fused in the reverberatory furnace.

In Saxony, and in England, the scoriæ are three times fused to separate the tin, after which they are pounded to separate the last portions of metal.



metal. As the vein of tin in the mines of Cornwall is always mixed or accompanied with a vein of copper, the tin must contain this latter metal, however great the precautions which may be attended to in the working.

We are acquainted with three kinds of tin in commerce.

1. Pure tin, such as that of Malacca, of Banca, and the soft tin of England. The tin of Malacca is cast in moulds which give it the form of a quadrangular truncated pyramid, with a small rim at its base. It is called, in France, *Etain en Chapeau*, or *en Ecritoire*. Each ingot weighs one pound.—The tin of Banca is in the form of oblong ingots, weighing from forty to forty-five pounds each.

2. The English tin, in large pigs, is cast into sticks of ten or twelve lines in diameter, and a foot and a half long.

3. The tin of the pewterers is alloyed with various metals. The law in France permits them to add copper and bismuth; and they of their own authority add zinc, lead, and antimony.

Every kind of tin enters into fusion with considerable facility, for it is the most fusible of the metals. If it be kept in fusion for a short time, exposed to the action of the air, the surface becomes wrinkled, and covered with a grey pellicle.



pellicle. If this first covering be taken off, the tin appears with all its brilliancy; but soon becomes dull, and is oxidized again. Tin gains one-tenth of its weight by this calcination. When the oxide is white, it is then called Putty. It is this oxide of tin which the makers of pewter spoons, who usually travel over the country, call the Dross of Tin. They are very careful to scum the metal as often as possible, to clear it of the dross; and by this means they avoid giving the peasant any more of his old pewter than that which they cannot contrive to take away from him. They are very well acquainted with the art of fusing this pretended dross into good tin, by heating it in contact with charcoal.

The putty of tin is used to polish hard bodies; and to render glass opaque, which converts it into enamel. Tin takes fire by a violent heat, according to Geoffroy; and a white oxide sublimes, while part of the tin is converted into a glass of an hyacinthine colour.

If tin be kept in fusion in a lined crucible, and the surface be covered with a quantity of charcoal to prevent its calcination, the metal becomes whiter, more sonorous, and harder, provided the fire be kept up for eight or ten hours.

Tin, and several other metals, may acquire a  
bril-



brilliancy they do not usually possess, by pouring them out at the moment before they would congeal in the crucible. This treatment secures them from the oxidation they suffer in cooling, when they are poured out too hot; and by this method, which is very simple, I have procured to tin and lead a degree of brilliancy which they would hardly be thought capable of exhibiting.

Tin, distilled in close vessels, affords a white sublimate in the neck of the retort, which Margraff took for arsenic; but Messrs. Bayen and Charlard have proved that it was not that substance.

The action of acids upon tin varies according to the degree of purity of the metal.

The sulphuric acid of commerce dissolves tin, by the assistance of heat; but part of the acid is decomposed, and flies off in the form of very penetrating sulphureous acid. Water alone precipitates this oxidized metal. Mr. Monnet has obtained crystals by calcination, which resemble fine needles, interlaced among each other. The sulphuric acid dissolves the oxide of tin much better.

The nitric acid devours tin. The decomposition of this solvent is so speedy, that the metal is seen to be precipitated, almost instantly, in a white oxide. If this acid be loaded with all  
the



the tin it is capable of calcining, and the oxide be washed with a considerable quantity of distilled water, a salt may be obtained by evaporation, which detonates alone in a crucible well heated, and which burns with a white and thick flame, like that of phosphorus. The nitrate of tin, distilled in a retort, swells up, boils, and fills the receiver with a white and thick vapour, which has the smell of nitric acid.

Mr. Baumé even pretends that the nitric acid does not dissolve tin; but Kunckel, and the famous Rouelle, have maintained the contrary. Messrs. Bayen and Charlard dissolved five grains in two gros of pure nitric acid, diluted with four gros of distilled water.

The muriatic acid dissolves tin, whether cold or heated. During the effervescence, a very fetid gas is disengaged. The solution is yellowish, and affords needle-form crystals by evaporation, which attract the humidity of the air. Mr. Baumé prepared this salt in the large way for the callico printers. Out of twelve pounds of tin, dissolved in forty-eight pounds of acid, he had a residue of two ounces six gros of a grey and soluble powder, which Margraff had taken for arsenic. Mr. Baumé has observed that the crystals of the muriate of tin differ according to the state of the acid. He obtained

6 crystals,



crystals, fimilar to thofe of the fulphate of foda, in needles, or in fcales like thofe of the acid of borax. Mr. Monnet afferts that he obtained, by the diftillation of a muriate of tin, a fat matter, a true butter of tin, and a liquor refembling that of Libavius.

The oxigenated muriatic acid diffolves tin fpeedily ; and the falt which it produces, poffeffes all the characters of the ordinary muriate, according to Mr. De Fourcroy.

That which is known by the name of the Fuming Liquor of Libavius, appears to me to be a muriate of tin, in which the acid is in the ftate of the oxigenated muriatic acid. To make this preparation, tin is amalgamated with one-fifth of mercury ; and this amalgam in powder is mixed with an equal weight of corrofive fublimate. The whole is then introduced into a retort, a receiver adapted, and diftillation proceeded upon by a gentle heat. An infipid liquor paffes over firft, which is followed by a fudden eruption of white vapours, which condense into a transparent liquor, that emits a confiderable quantity of vapours by mere expofure to the air. The refidue in the retort, for an analysis of which we are indebted to Mr. Rouelle the younger, confifts of a flight lining in the neck of the retort, which contains a fmall quantity



tity of the fuming liquor, some muriate of tin, muriate of mercury, and running mercury. The bottom of the vessel contains an amalgam of tin and mercury; above which lies a muriate of tin of a grey white, solid and compact, and which may be volatilized by a strong heat.

The nitro-muriatic acid dissolves tin with vehemence: a violent heat is excited; and it frequently happens that a magma is obtained resembling pitch, which becomes harder in process of time. This happens when the very concentrated acid has dissolved too much of the metal; and these inconveniences may be obviated by adding water in proportion as the solution proceeds.

The solution of tin which constitutes the composition for scarlet, is made with the common aqua fortis, prepared with saltpetre of the first boiling. This is a kind of nitro-muriatic acid, which unfortunately varies in its properties, according to the too variable proportions of muriate of soda and nitrate of pot-ash. For this reason the dyers are continually making complaints either that the aqua fortis precipitates, which happens when it contains too small a quantity of muriatic acid; or that it affords an obscure colour, which depends on an excess of the same acid. The first inconvenience is re-



medied by dissolving sea salt, or sal ammoniac, in the aqua fortis; and the second by adding saltpetre.

The most accurate proportions to make a good solvent for tin, are, two parts of nitric acid, and one of muriatic acid.

Tin is likewise soluble in the vegetable acids. Mr. Schultz, in his Dissertation *De Morte in Olla*, has demonstrated the solubility of this metal in acids. Vinegar corrodes it by a gentle heat, according to the experiments of Margraff.

Most of the tin in commerce is alloyed with various metals. That of England contains copper and arsenic artificially, according to Geoffroy; and naturally, according to the Baron Dietrich, Sage, &c. The tin of the plumbers or pewterers, called Pewter, contains several metals. The ordonnance in France permits them to add a small quantity of copper and bismuth. The first metal renders it hard; and the latter restores the brightness which would else have been impaired by the copper, and renders it more sonorous. The pewterers take upon themselves to add antimony, zinc, and lead; the antimony hardens it, the zinc renders it whiter, and the lead diminishes its value. It is a desirable circumstance to possess the means of ascertaining the nature and proportions of these



these alloys. We are indebted for the following processes to Messrs. Bayen and Charlard.

A. When tin contains arsenic, the solution in the muriatic acid exhibits a black powder which consists of arsenic separated from the tin. This method is capable of rendering the two thousand and forty-second part of alloy perceptible.

B. If the tin contains copper, the muriatic acid, which attacks tin with facility, precipitates the copper in the form of a grey powder, provided there be no excess of acid, and the solution be made without heat. The copper is likewise precipitated by a plate of tin immersed in the solution.

C. Bismuth is shewn by the same process as the copper.

D. To ascertain the mixture of lead, the nitric acid must be used, which corrodes the tin, and dissolves the lead.

The pewterers have two methods of assaying this metal.

1. The assay of the stone, which consists in pouring it into a hemispherical cavity made in a calcareous stone, and terminating in a channel or groove. The workman attentively observes the phenomena of its cooling; and from these circumstances, as well as from the crack-



ling or noise which the tail of the assay affords when bended, he judges of the purity of the metal.

2. The assay by the ball consists merely in a comparison of the weight of pure tin with that of adulterated or alloyed tin, poured into the same mould.

It cannot but be immediately perceived that these methods are very imperfect.

The various metals which are prejudicial to health, are not added to the tin in a sufficiently great proportion to produce any dangerous effects. It seems that Margraaf was deceived by some foreign circumstance, when he affirmed that the tin of Morlaix contains thirty-six grains of arsenic in the half ounce; for this quantity is more than sufficient to render the metal as brittle as zinc. Messrs. Bayen and Charlard found no arsenic in the tin of Banca and of Malacca. The tin of England never contains more than three-fourths of a grain of arsenic in the ounce of metal: and supposing this to be the maximum, the daily use of tin cannot be dangerous; since a plate in which arsenic existed in this proportion, lost no more than three grains per month by constant use, which amounts to the five thousand seven hundred and sixtieth part of a grain of arsenic lost daily. The experiments  
which



which these two skilful chemists have made upon animals, by mixing arsenic in larger proportions with tin, are sufficient to remove every apprehension concerning the use of this metal.

The lead alone may be productive of dangerous consequences, because the pewterers add it in a very considerable proportion.

The combination of tin with sulphur forms aurum musivum, or mosaic gold. The process for making it which has best succeeded in my hands, is that described by the Marquis de Bouillon. It consists in forming an amalgam of eight ounces of tin and eight ounces of mercury. For this purpose, a copper mortar is heated, and mercury poured into it; and when it has acquired a certain degree of heat, the melted tin is poured in, and the mixture agitated and triturated till cold. Six ounces of sulphur, and four ounces of sal ammoniac, are then mixed; and the whole put into a matraass, which is to be placed on a sand bath, and heated to such a degree as to cause a faint ignition in the bottom of the matraass. The fire must be kept up for three hours. The aurum musivum thus obtained is usually beautiful: but if, instead of placing the matraass on the sand, it be immediately exposed upon the coals, and strongly and suddenly heated, the mixture will take fire,

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and



and a sublimate will be formed in the neck of the vessel, which consists of the most beautiful aurum musivum. I have obtained it by this process of a dazzling colour, in large hexagonal scales.

The mercury and the sal ammoniac are not in strictness necessary to the production of aurum musivum. Eight ounces of tin dissolved in the muriatic acid, precipitated by the carbonate of soda, and mixed with four ounces of sulphur, produced the Marquis of Bouillon a fine aurum musivum: but this is not capable of increasing the effects of the electrical machine; which proves that the composition owes its virtue in that respect to the mercury it contains in the proportion of six to one, when prepared in the former process. This preparation is used to give a beautiful colour to bronze, and to increase the effects of the electrical machine by rubbing the cushions.

The Baron Kienmayer has described the following amalgam, composed of two parts of mercury, one of zinc, and one of tin:—The zinc and the tin are to be fused, and mixed together with the mercury; and the mixture agitated in a wooden box, internally rubbed with chalk. The mass is then to be reduced to a fine powder; and employed in that state, or mixed with grease.



grease. The effect of this amalgam is surprising; for by this means the power of electrical machines is inconceivably augmented.

The amalgam of tin is capable of crystallization. Mr. Sage's process consists in pouring two ounces of melted tin into a pound of mercury. After having introduced this mixture into a retort, he urged it by a violent fire for five hours on the sand bath. No mercury was disengaged; but the tin was found in a crystallized state above the mercury, which had not entered into combination. The lower part of this amalgam is composed of grey brilliant crystals in square plates, thin towards their edges, leaving polygonal cavities between each. Every ounce of tin retains in its crystallization three ounces of mercury.

The amalgam of tin is used to silver looking-glasses. For this purpose, a leaf of tin is spread out upon a table of the size of the glass, mercury is poured upon it, and spread about with a brush. This being done, a larger quantity of mercury is poured upon the tin, so as to form a covering of more than one line in thickness. The glass is slid upon this covering, by presenting one of its edges; taking care at the same time that its surface shall be beneath the level of the mercury, in order that the impurities



which might hinder a perfect contact may be driven before it. The plate of glass is then loaded with weights equally distributed over its whole surface ; by which means all the excess of mercury is pressed out, and flows away through channels made in the edges of the table. The air being driven out from between the amalgam of tin and the glass by this strong compression, serves greatly to render the amalgam adherent. Several days are required to elapse before it be sufficiently dry to admit of removing the glass.

Tin alloyed with copper forms bronze, or bell-metal. Seven parts of bismuth, five of lead, and three of tin, form an alloy which liquefies in boiling water.

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## C H A P. X.

### *Concerning Iron.*

**I**RON is the most generally diffused metal in nature. Almost every mineral substance of this globe is coloured with it ; and its various alterations produce that truly astonishing variety



riety of colours, which are comprehended between the blue and the deepest red. This metal likewise exists in the vegetable kingdom, where it constitutes an almost inseparable principle. It even appears to be one of the products of organization, or vegetation; for it is found in vegetables which are supported merely by air or water. It is indeed contrary to sound philosophy to suppose that all the iron with which earths are impregnated, must arise from the wearing of ploughshares: for, not to mention that the plough has not passed every where, we see iron daily formed in vegetables. There is no reason to fear that the metal should on this account become too abundant; because it is continually destroyed by passing to the state of oxide.

If, on the other hand, we cast our attention towards the infinite number of uses to which this metal is applied in society, we shall perceive that it is perhaps the most essential to be known, because it is the most diffused, the most useful, and the most employed.

This metal is of a white livid colour, inclining to grey, obedient to the magnet, and gives fire with quartz; which last circumstance is attributed to the fusion and rapid combustion of



particles of the metal detached by the stroke. It is the lightest of all metals except tin. One cubic foot of forged iron weighs five hundred and forty-five pounds. The specific gravity of fused iron is 7,2070.—See Briffon.

Iron is very hard, susceptible of a fine polish, and very difficult of fusion. It may be drawn into very fine wire, of which the strings of the harpsichord are made. It becomes hard by hammering, without heat; but when assisted by heat, it may be hammered into every imaginable form.

Iron is universally dispersed; but, by common consent, those places, or matrices, in which the iron is sufficiently abundant to be wrought with profit, are called Iron Mines, or Ores.

Iron is found native, without mixture, in several places. We shall not here mention those ridiculous assertions, which have no other merit than that of having been authorized by the suffrages of certain celebrated men.—“ALBERTUS MAGNUS decidisse cœlo, imbre, massam ferri centum librarum. *Petermannus*, magnâ tempestate, cum projectu multorum lapidum, cœlo molem ferri decidisse, quæ in longitudine sexdecim, in latitudine quindecim, in crassitie duos, pedes habuerit:” that is, of the weight  
of



of forty-eight thousand pounds, and containing four hundred and eighty cubic feet.—Becher Supplem. in Phys. Subter. cap. iii. p. 599.

We are indebted to Lehman for a description of a piece of native iron possessed by Margraaf, which came from Eibenstock in Saxony. The grain was distinguishable on both sides.

Henckel possessed a small piece incrustated with a yellow earth; and the cabinet of the Royal School of Mines possesses one which is covered with spathose iron ore. Adanson and Wallerius affirm that it is found in Senegal; and Rouelle received a piece from thence which was very malleable. Simon Pallas speaks of a mass of native iron found near the great river Jenesei in Siberia. This iron is very spongy, very pure, perfectly flexible, and proper to be formed into instruments by a moderate fire. It is naturally incrustated with a kind of varnish which preserves it from rust.

Mr. Macquart doubts the legitimacy of the native iron, described by Pallas: he thinks that it may be considered as fused iron. Mr. De Morveau does not believe in the existence of native iron.

Though some doubts may be raised concerning the legitimacy of these pieces, and there may be reasons to consider some of them as consequences



quences of the action of fire, we cannot however refuse to admit of the existence of native iron, after the depositions, facts, and attestations which present themselves on all sides in support of this truth.

Iron, slowly cooled, crystallizes in octahedrons almost always implanted one in the other. We are indebted to Mr. Grignon for this observation. I am in possession of a piece of iron entirely covered with small tetrahedral, flat, and truncated pyramids. Some of the pyramids have a base of one line in breadth. It comes from the frontiers of the Comté de Foix. This iron is very seldom found unaltered by foreign admixtures; but I think we may consider all the iron ores which are attracted by the magnet, as containing the native metal, dispersed in some gangue: and we shall attend to these species before we treat of the oxides and martial salts.

## A R T I C L E I.

Concerning Iron Ores which are attracted by the Magnet.

1. The octahedral iron ore.—This ore has the form of octahedrons, isolated, and dispersed in a gangue of schistus, or calcareous stone.



The crystals are grey, very regular in their form, and strongly bedded in the stone. Their size is from half a line to six or seven in diameter. Corfica and Sweden afford this kind.

Mr. Sage observes that octahedral crystals of iron are sometimes found in the finest white marble of Carara. The black ferruginous sand which accompanies the hyacinths in the brook of Expailly, is an octahedral iron ore, obedient to the magnet.

2. Iron ore in small plates or scales.—The small plates or scales which are attracted by the magnet, and are found in most rivers which contain gold, are an iron ore, nearly in the metallic state. This sand forms the residue which is left after the precious metal has been taken up by amalgamation. It is mixed with fragments of quartz, garnets, &c. I found a large quantity in the sand of the river of Ceze: it was also sent me from the neighbourhood of Nantz. I have received some likewise from Spain; and this sand has afforded me certain phenomena which appear to entitle it to a particular rank among the metals. Acids dissolve it by the assistance of heat; and always without effervescence, or the disengagement of gas. It communicates the same colour to the nitro-muriatic acid as platina



platina does. It is indecomposable by heat, either in the open fire, or in open vessels. I have endeavoured to reduce it by all the known fluxes, but in vain. It precipitates in the flux, mixes with it, and recovers its form and magnetic virtue by pulverizing the mass. It possesses several characters of the siderotete, or phosphate of iron.

3. Iron dispersed in stones renders them obedient to the magnet. The ophites, the serpentine, the micas, the pot-stones, and several marbles, are in this situation. Iron diffeminated in a gangue of quartz, or very hard jasper, forms emery, which on account of its hardness is used to grind and polish glass. It comes to us from Jersey and Guernsey, where it is plentifully found.

The magnet itself is nothing else but the iron we speak of, modified in such a manner as to afford a passage to the magnetic fluid, and to exhibit the known phenomena. The magnet is sometimes found in a regular form. Mr. Sage affirms that he possesses a small piece of magnet from St. Domingo, on which octahedrons are distinguishable. We likewise read, in the General History of Voyages, that at twenty leagues from Solikamskai in Siberia magnets are found of a cubical



cubical form and greenish colour, of a lively brilliant appearance, which are reducible into glittering scales by pulverizing.

The magnet varies in its quantity of metal. Those of Sweden and Siberia are very rich in iron; but the magnetic force is not in proportion to the iron they contain.

There is reason to think that the magnetic agent is a modification of the electric power.

1. Iron which remains a long time in an elevated position becomes magnetic. 2. Instruments of iron struck with lightning are usually magnetized. 3. Two pieces of iron may be magnetized by rubbing them against each other in the same direction. 4. Black iron ores are found in Sweden which are attracted by the magnet, and whose metallic particles are sometimes so weakly connected together that they are reducible into powder. We have several species of these ores in Languedoc.

This species is in general very rich, and affords near eighty pounds of iron per quintal.

5. Iron appears to exist in the metallic state in some other species, such as the specular iron ore. But the metallic state is less evident and characteristic, the metallic qualities being more changed; and these ores are less attracted by the magnet.

These



These iron ores frequently exhibit metallic plates of a brilliancy equal to that of steel, and unalterable in the air. The ore of Mont d'Or, that of Framont in the principality of Salm, and those of the mountains of Vosges, have afforded us very curious specimens. These plates are sometimes hexagonal, formed by two hexahedral pyramids truncated near their base.

The specular iron ore of Framont afforded Mr. Sage fifty-two pounds of iron in the quintal: the iron is very ductile, and acquires much fibre.

The celebrated iron ore of the island of Elbe is of this kind, but it has not the plated form. Its crystals are lenticular, with brilliant facets, which are dodecahedrons with triangular planes. These beautiful groupes of crystals are sometimes shaded with the most lively colours. White clay, rock crystal, cupreous pyrites, &c. are found among them.

The Lucquese work this ore in the Catalan method, by stratifying charcoal and the ore, one layer over the other. The fire is kept up by good bellows; and when all the coal is consumed, the iron is found collected together in a mass, which is carried to the hammer.

The eisenman is a scaly specular ore. When it is rubbed, brilliant particles are detached from  
it;



it; which has caused the miners of Dauphiny to give it the name of Luifard.

The eisenram is an iron ore of a brilliant red colour, which contains plumbago and iron.

## ARTICLE II.

### Concerning Sulphureous Iron Ores, or the Sulphures of Iron.

The union or combination of iron and sulphur forms the sulphureous iron ore, martial pyrites, sulphure of iron, &c. These sulphures are very abundant, and are evidently formed by the decomposition of vegetables. I have several times found pieces of wood buried in the earth perfectly incrustated with pyrites. The effect of subterraneous fires is owing only to the mixture of these sulphures with the remains of vegetables. Those species of coal which effloresce in the air, owe their decomposition only to the pyrites with which they are penetrated. It is likewise to the decomposition of the pyrites that we must refer the heat of most mineral waters. The sulphure of iron sometimes crystallizes in cubes, and often in octahedrons. The union of a number of octahedral



hedral pyramids with their points towards a common centre, forms the globular pyrites.

When the sulphur is dissipated, it sometimes happens that the pyrites loses neither its form nor its weight. It then becomes brown, is attracted by the magnet, and is called the Brown or Hepatic Iron Ore.—See De Lisle.

But the decomposition of pyrites most commonly produces the sulphuric acid, which seizes the iron, dissolves it, and forms an efflorescence on the surface. Advantage has even been taken of this property of the pyrites to establish manufactories of sulphate of iron, or copperas. The two valuable establishments which have been made of this kind, in the vicinity of Alais, work certain strata of a hard ponderous pyrites. These are formed into heaps upon areas, where the ground is slightly inclined. The efflorescence is accelerated by watering the pyrites, grossly broken, with water. This fluid dissolves all the salt which is formed, and carries it into reservoirs, where the solution suffers all the foreign matters it may contain to subside. It is left at rest in these reservoirs, in which the sun produces a slight concentration of the fluid; and the concluding evaporation is made in leaden cauldrons, with the addition of old iron, to saturate the acid with as much of that metal



as possible. The crystallization is performed in basons, in which pieces of wood are disposed to assist the formation of crystals. These two manufactories in Languedoc are capable, in their present state, of furnishing upwards of forty thousand quintals of copperas, if the demand required it.

In order to facilitate the vitriolization, it is necessary to give access to the air, because the concurrence of this element is necessary to form the sulphuric acid.

The sulphate of iron crystallizes in rhomboids.

It effloresces in the air, and gradually loses its fine green colour by the dissipation of its water of crystallization.

If the sulphate of iron be exposed to heat, it liquefies, boils, becomes thick, and is reduced into powder. This powder, mixed with pulverized nut galls, forms a dry ink, which several persons sell as a secret, and which requires only the addition of water to render it fit for use.

The same powder, urged by a stronger heat, suffers its acid to escape; after which there remains only a martial earth, or metallic oxide, known by the name of Colcothar.

I attribute the formation of all the yellow or red earths, commonly called ochres, to a similar



decomposition of the pyrites. The heat produced by the decomposition of the pyrites has determined the respective colours of these earths ; and they may be caused to pass artificially through these various shades, by treating them with various degrees of fire. I have discovered, in the diocese of Uzes, banks of ochre of such an uncommon fineness, and so very pure, that calcination converts it into a brown red, superior to every thing before known in trade. The manufactory which has been established under my care, has acquired all the celebrity which the superiority of its products could not but necessarily afford it. My experiments on these ochres, and the advantages which they may afford to the arts, may be seen in the work which I have published on this subject, printed for Didot the elder, at Paris.

I likewise found at Mas-Dieu, near Alais, a stratum of red ochre of so beautiful a colour, that it could scarcely be imitated.



## ARTICLE III.

Concerning the Spathose Iron Ores, or Carbonates of Iron.

The carbonic acid is sometimes combined with iron in ores; and the resemblance between this iron and spar, has procured it the name of the Spathose Iron Ore.

The formation of this ore appears to be owing to the mutual decomposition of the carbonates of lime, and the sulphates of iron. A solution of copperas, in which calcareous spar was suffered to remain, produced this ore, according to the experiments of Mr. Sage.

Bergmann obtained from the ores of this kind, which he analysed, thirty-eight ounces of the oxide of iron, twenty-four ounces of the oxide of manganese, and fifty ounces of calcareous earth. It appears therefore that this ore contains two metals united by a calcareous cement, which crystallizes always in its own form, as we find in the lapis calaminaris, the calcareous grit, &c.

The spathose iron ores are wrought at Castiel, in the diocese of Narbonne, at Bendorf



on the banks of the Rhine, at Eifenartz in Styria, &c.

#### A R T I C L E IV.

Concerning the Bog Ores of Iron, or Argillaceous Iron Ores.

These ores consist merely of a martial oxide, in a state of greater or less purity, mixed with earthy substances of the nature of clays.

They appear to have been deposited by water ; and are usually disposed in strata, which are frequently marked out, and as it were separated, into small prisms, whose formation arises simply from the shrinking of the clay.

1. The eagle-stone, or ætites, ought to be ranked among the bog ores of iron. They are geodes of a round or oval form, having a hard external covering, while the cavity includes a detached nodule ; and the noise produced by shaking one of these stones, arises from the nodule being at liberty to move within the stone.

The name of eagle-stone has arisen from a notion, formerly entertained, that eagles placed it in their nests to facilitate the laying of their eggs ; and wonderful powers of rendering labours



hours safe and easy, were attributed to it in the times of superstition.

2. We are acquainted with an iron ore in round pieces, resembling bullets, of several lines in diameter, which ought to be considered as a variety of the preceding. An ore of this kind was begun to be wrought at Fontanez, near Sommieres; and we find a considerable quantity of these metallic globules among our red earths in the neighbourhood of Montpellier.

3. The purest oxide of iron, worn and carried along by waters, and afterwards deposited, forms strata of various appearances and colours. These are called hæmatites.

The colours arise from the various degrees of alteration in the oxide. They vary from yellow to the deepest red. The red hæmatites is used in the arts to burnish gold or silver. It is cut into long pieces, which when polished are known by the name of burnishers. This blood-stone is sometimes soft enough to be used instead of a crayon for drawing.

Its figure is likewise subject to prodigious variation. It often appears as if composed of small prisms applied one against the other, in which case it is called the fibrous hæmatites. In other specimens it is tuberculated. It is very frequently found in compact irregular masses,



such as those of the ores of the county of Foix. This must naturally exhibit the same variety of forms as the calcareous stalactites, because its mode of formation is nearly the same.

## A R T I C L E V.

Concerning Native Prussian Blue, or the Prussiate of Iron,

Becher speaks of a blue earth found at Turinge. Henckel informs us that blue martial earth is found at Schneeberg and at Eibenstock. Cronstedt has described a native Prussian blue: Mr. Sage found it in the turf of Picardy. It is likewise found in Scotland, in Siberia, &c. and I possess a sulphure of iron in a state of decomposition, which exhibits a true prussiate of iron upon one of its surfaces.

## A R T I C L E VI.

Concerning Plumbago, or the Carbure of Iron.

The name of plumbago is at present confined to that shining substance of a blackish blue colour, which is used to make the pencils called  
black-



black-lead pencils. It has a greasy feel, exhibits a tuberculated fracture, soils the hands, and leaves a black trace upon paper.

Plumbago is found in many places: that of commerce is brought to us from Germany. We receive it likewise from Spain, from America, and from England. It is also found in France. This mineral is almost always disposed in separate masses in the bowels of the earth; and it is probably on account of this form, that the ancients denoted it by the words *Glebæ Plumbariæ*.

The plumbago of England differs from the other specimens in its texture, which is much finer, and of a greater degree of brilliancy. The English do not take a larger quantity out of the mine than the market demands, in which they are careful to keep up the price.

The most plentiful mine is in the county of Cumberland.

The plumbago of Spain is always accompanied with pyrites, which effloresce on the surface of the pieces; either in small crystals, similar to those of the sulphate of iron; or in a kind of silky vegetation, analogous to that of plume alum. It is dug up in the neighbourhood of the town of Ronda, at the distance of four leagues from the Mediterranean sea. It is the



worst kind which comes to market, and is used only to give a shining black colour to iron utensils.

The American plumbago, which Mr. Woulfe procured for Mr. Pelletier, breaks easily, and exhibits small quartzose grains in its internal part, as well as slight traces of a whitish clay. It is found in separate masses; and its texture appears to consist of the union of an infinity of small scaly parts, which at first sight might cause it to be taken for molybdena.

France likewise possesses plumbago, and the chevalier Lamanon observed it in Upper Provence. The mine is situated near Col de Bleoux. The black lead is found between two strata of clay, not more than a few lines in thickness. It forms a stratum of four inches thick; or rather the stratum consists of separate masses, which are sometimes several feet in length. It is accompanied by a vein of pyrites. The inhabitants of Bleoux sell this product at Marseilles at about fifteen livres per quintal. Mr. De la Peyrouse found plumbago with tourmalines in the county of Foix, and Mr. Darcet brought it from the Pyrenean Mountains.

Plumbago is indestructible by heat without the presence of air. Mr. Pelletier exposed it

to



to distillation, in the pneumato-chemical apparatus, by a violent fire during six hours, without the plumbago having lost weight, or suffered any other change. He exposed two hundred grains in a well-closed porcelain crucible to the fire of the manufactory at Seves, and it lost only ten grains. But when it is calcined with the concurrence of air, it then burns, and leaves but a small quantity of residue. Messrs. Quist, Gahn, and Hielm observed that one hundred grains, treated under a muffle in a shallow vessel, left only ten grains of oxide of iron. Mr. Fabroni dissipated the whole of a portion of plumbago exposed under the muffle. This calcination is a slow combustion, which is facilitated by causing the matter to present a large surface, and agitating it from time to time.

If one part of plumbago, and two of very caustic dry alkali, be heated in a retort with the pneumato-chemical apparatus, the alkali becomes effervescent, hydrogenous gas is obtained, and the plumbago disappears. This beautiful experiment proves that the small quantity of water contained in the salt is decomposed; and that its oxigene, by combining with the carbone of the plumbago, forms the carbonic acid. The experiment published by Scheele



Scheele has been repeated and confirmed by Mr. Pelletier.

The sulphuric acid does not act upon plumbago, according to Scheele. Mr. Pelletier has observed that one hundred grains of plumbago, and four ounces of oil of vitriol, being digested in the cold for several months, the acid acquired a green colour, and the property of congealing by a very slight degree of cold. The sulphuric acid distilled from plumbago, passes to the state of the sulphureous acid; at the same time that carbonic acid is obtained, and an oxide of iron is left in the retort.

The nitric acid has no action upon plumbago unless it be impure. Eight ounces of nitric acid, distilled from half a gros of purified plumbago, neither altered its shining appearance, nor deprived it of its unctuous feel.

The muriatic acid dissolves the iron and the clay which contaminate native plumbago. Messrs. Berthollet and Scheele availed themselves of this method to purify it. The liquor being decanted after digestion upon the plumbago, the residue is then washed, and submitted to distillation to separate the sulphur. The muriatic acid alone has no action upon plumbago, but the oxygenated muriatic acid dissolves it;



it; the result being a true combustion effected by the oxigene of the acid, and the carbone of the plumbago.

If ten parts of the nitrate of pot-ash be fused in a crucible, and one part of plumbago be thrown thereon by a little at a time, the salt will deflagrate, and the plumbago will be destroyed. The matter which remains in the crucible consists of very effervescent alkali, and a small portion of martial ochre.

If plumbago be distilled with muriate of ammoniac, the muriate sublimes, coloured by the iron.

All these facts prove that plumbago is a peculiar combustible substance, a true charcoal combined with a martial basis. Plumbago is more common than is imagined. The brilliant charcoal of certain vegetable substances, more especially when formed by distillation in close vessels, possesses all the characters of plumbago. The charcoal of animal substances possesses characters still more peculiarly resembling it. Like it they are difficult to incinerate, they leave the same impression on the hands and upon paper; they likewise contain iron, and become converted into carbonic acid by combustion. When animal substances are distilled by a strong fire, a very fine powder sublimes, which attaches



taches itself to the inner part of the neck of the retort. This substance may be made into excellent black lead pencils, as I myself have proved.

Carbone may be formed in the earth by the decomposition of wood together with pyrites; but the origin of plumbago appears to me to be principally owing to the ligneous, and truly indecomposable, part of the wood, which resists the destructive action of water in its decomposition of vegetable substances. This ligneous substance, disengaged from the other principles, must form peculiar depositions and strata; and Mr. Fabroni has assured me that the formation of plumbago in water is a common phenomenon, of which he had several times been a witness. This chemist, by his letter of the thirtieth of January 1787, informs me that, in the dominions of the king of Naples, there are wells dug expressly for the purpose of collecting an acidulous water, at the bottom of which wells a quantity of plumbago is collected every six months.

He supposes that the black mud which is found beneath the pavement of Paris is plumbago formed in the humid way.

There are likewise districts in Tuscany where plumbago is formed in the humid way.



This substance is of considerable use in the arts. It has been at all times applied to the purpose of making pencils, the most esteemed of which are those which come from England. They are made at Kewick in the county of Cumberland. The piece of plumbago is sawed into very thin plates. The edge of one of these plates is fitted into a groove struck in a wooden cylinder; and the thin plate of plumbago is then cut off in such a manner that the cavity of the small cylinder remains perfectly filled.

The dust of plumbago is used to lubricate certain instruments; and it is likewise made into pencils of an inferior quality, by kneading it up with mucilage, or by fusing it with sulphur. The fraud may easily be discovered by the assistance of fire, which burns the sulphur; or by means of water, which dissolves the mucilage.

Plumbago is likewise used to defend iron from rust. The hearths and plates of chimneys, and other similar utensils, which appear very bright, owe their colour to plumbago. Homberg has communicated a process, in the year 1699, in which plumbago is applied to this use. Eight pounds of hogs-lard are melted with a small quantity of water, with the addition of four ounces of camphor. When this last is fused,  
the



the mixture is taken from the fire; and, while it is yet hot, a small quantity of plumbago is added, to give it a leaden colour. When this is to be applied, the utensils must be heated to such a degree, that the hand can scarcely be applied to them. In this state the composition must be rubbed on them, and afterwards wiped when the piece is dry.

Those who prepare small shot, make use of black lead to polish and glaze it: the shot is rolled or agitated together with a quantity of plumbago. Plumbago is likewise used to make razor strops. When kneaded up with clay, it forms excellent crucibles, which we receive from Passaw in Saxony. One part of plumbago, three of argillaceous earth, and a small quantity of cows dung very finely chopped, form an excellent lute for retorts. Mr. Pelletier has used it with great advantage. This lute is exceedingly refractory; and the glass will melt without the covering changing its form.

To make the assay of an iron ore, I find the following flux very advantageous:—I mix four hundred grains of calcined borax, forty grains of flaked lime, two hundred grains of nitrate, and two hundred of the ore to be assayed. I pulverize this mixture, and place it in a lined crucible, which I cover. The heat of a forge furnace



furnace is sufficient to effect the reduction. In the space of half an hour, the button of metal is found deposited at the bottom of the vitrified flux.

The process for working iron mines varies according to the nature of the ore. The metal is sometimes so little altered, and so abundant, that nothing more is necessary than to mix it with the coal, and fuse it. This simple and economical process forms the basis of the Catalan method, which may be employed in treating the spathose iron ores, those of Elbe, the hæmatites, and other rich and pure ores. But it cannot be applied to such as contain much foreign matter capable of becoming converted into slag. For this reason, the experiments made in the county of Foix on the ores of various countries, and various qualities, have not succeeded. On this head, the work of Mr. De la Peyrouse, and the Memoirs of the Baron de Dietrich, may be consulted.

The furnaces in which iron is fused, are from twelve to eighteen feet in height. Their internal cavity has the form of two four-sided pyramids joined base to base. The only flux added to the ore is the calcareous stone, named (by the French) *castine*, if the ore be argillaceous; but, if the gangue be calcareous, the workmen  
employ



employ argillaceous earth, which is named *berbue*.

The furnace is charged at the upper part; and the fire is excited by bellows, or hydraulic machines. The ore melts as it passes through the coal; and is collected at the bottom, where it is maintained in a liquid state. At the end of every eight hours it is suffered to flow out into the mould, or hollow channel made in the sand.

Crude iron, cast in suitable moulds, forms chimney-backs, pots, cauldrons, pipes, and an infinity of utensils or vases, which could not be obtained without difficulty by forging the iron. The works which are established at Creusot in Burgundy surpass every thing which can be desired in this species of industry.

This first product is called Cast or Crude Iron. It is brittle; but may be rendered ductile by heating it again, and hammering it. For this purpose the pig iron is fused again, and stirred while in the state of fusion: after which it is carried to the forge hammer. By this treatment the iron becomes ductile, assumes a fibrous texture, and is formed into square or flat bars for the purposes of trade.

Iron is likewise capable of a degree of superiority, which is given to it by placing it in contact



tact with coaly substances, and softening it to such a degree that these may penetrate into its texture. It is then known by the name of Steel. We are indebted to Mr. Jars for very interesting accounts of the steel manufactories in England. The manufactory established at Amboise is not inferior to those of England, as was ascertained by comparative experiments made upon the products of the several manufactories, at Luxemburg, on Friday the 7th of September, 1786.

We may therefore divide the different states of iron into cast or crude iron, iron properly so called, and steel. It is clear that these three states are nothing more than modifications of each other; but the circumstances on which they depend, and the principle which establishes their difference, were till lately unknown.

The celebrated Bergmann has given an analysis of the various states of iron, and has drawn up the following table:

	Cast Iron.	Steel.	Iron.
Inflammable Air	40	48	50
Plumbago -	2 - 20	0 - 50	0 - 12
Manganese -	15 - 25	15 - 25	15 - 25
Siliceous Earth	2 - 25	0 - 60	0 - 175
Iron -	80 - 30	83 - 65	84 - 45



This celebrated chemist has confirmed by his results the conclusion of Reaumur, who always considered steel as an intermediate state between crude and malleable iron.

We are indebted to three French chemists, Messrs. Monge, Vandermonde, and Berthollet, for a quantity of much more accurate information respecting all these states.

We may consider iron ores as natural mixtures of iron, oxigene, and various foreign substances. When an ore is wrought, the object of the operator is to clear the iron of all these matters. To effect this separation, the ore is thrown into the smelting furnaces, with different proportions of charcoal. These matters are heated together until they arrive at the hottest part where the mixture falls; and, after suffering the strong action of the fire, is precipitated in fusion, and forms a fluid mass at the bottom of the furnace. The earths and stones, nearly in a vitrified state, float above the fluid; and the oxigene, being partly driven out, remains likewise in a greater or less quantity in the crude iron. The crude iron is either white, or grey, or black. In our enquiries concerning the cause of these three kinds of iron, and their qualities, we can refer them only to the proportions  
of



of foreign principles contained in the crude iron. These principles are carbone and oxigene.

1. Crude iron contains carbone. The ladles which are used to agitate, take up, and pour out this melted metal, become covered with a coating of plumbago, which contains nine-tenths of carbone; and cast iron, strongly heated in contact with the coal, suffers a part to escape or exude from its surface when it is slowly cooled. Crude iron emits sparks when it is heated; the acids which dissolve it always leave a residue which is purely carbonaceous. The hydrogenous gas, which is obtained by treating these irons with acids, always affords the carbonic acid by combustion.

2. Crude iron contains oxigene. Several mineralogists attribute the fragility and brilliancy of crude iron to its still containing iron in the state of oxide. This opinion, which is generally adopted, supposes the existence of oxigene. Crude iron, urged by a violent heat in close vessels, affords the carbonic acid, and passes to the state of soft iron; because its oxigene then unites to the carbonaceous principle, and constitutes the carbonic acid, which exhales, and clears the crude iron from the two principles which altered its quality.

Oxigene and carbone exist therefore in crude  
A a 2 iron,



iron, but they may exist in three different states—1. A large quantity of carbone, and a small quantity of oxigene. 2. An exact proportion between these two principles. 3. Much oxigene, and a small quantity of carbone.—Now we find these three states in the three kinds of crude iron which we have distinguished, as is proved by analysis; and, as we may judge by the secondary processes, to correct these imperfections, or to convert crude iron to the malleable state.

1. In the first case, that iron which contains an excess of carbone is agitated or stirred as it flows out. It is kept a long time exposed to the action of the bellows, and the smallest possible quantity of charcoal is made use of. We see that in this process the properest methods are used to facilitate the combustion of this excess of the carbonaceous principle.

2. In the second case, that kind of iron in which the principles exist in accurate proportions, requires only the action of heat to unite and volatilize the two foreign principles. The crude iron is put into a state of ebullition by the disengagement of the acid which is formed, and exhales.

3. In the third kind, or that which contains oxigene in excess, the bellows are urged less violently



violently ; and the metal is penetrated with coal, in order to combine with the oxigene. Here therefore we see theory and practice go together. The former explains the usual manipulations, and affords us principles in cases wherein experiment too frequently fails.

Steel is a kind of iron which contains carbone only ; and its existence may be proved by all the experiments which have been mentioned as demonstrations that crude iron contains it.

Carbone may be given to iron—1. In the fusion of the ore. 2. Or, afterwards, by the cementation of iron with coaly substances.

1. In some parts of Hungary, and in the county of Foix, iron ores are wrought which contain the metal nearly in the disengaged state ; and the cast iron, when duly hammered, affords iron and steel in a greater or less quantity, according to the management of the fire, the quantity of air afforded by the tuyere, the quantity of coal made use of, and the nature of the ore. In this operation, the iron being scarcely at all calcined in the ore, becomes charged with coaly matter only, and the result is steel.

2. If the coaly principle be combined with iron in a ductile state, and deprived of all foreign matter, the combination being effected by



cementation or otherwise, the iron will pass to the state of steel; and the qualities of this steel will vary according to the proportions of carbone. The purity of the iron, and the care which is taken to avoid the oxidation of the metal, establish the various kinds of steel which are met with in commerce.

The nature and the principles of steel being once admitted and established, the following facts will explain themselves.

1. Since steel contains no foreign principle but carbone, it is not surprising that it remains unchanged by a violent heat in close vessels.

2. Steel, repeatedly heated, and exposed while hot to a current of air, loses its properties, and passes again to the state of soft iron.

3. Steel kept plunged for a time in crude iron in which oxigene predominates, becomes itself converted into soft iron.

4. Soft iron kept for a time plunged in crude iron, wherein carbone predominates, becomes converted into steel.

5. Iron, by passing to the state of steel, increases in weight one hundred and seventieth part.

Ductile iron would be a very soft metal, if it were cleared of all foreign substances.

From all these facts we may conclude—

1. That



1. That crude iron is a mixture of iron, carbone, and oxigene.
2. That the products of crude iron are white, grey, or black, according to the proportions of oxigene and carbone which it contains.
3. That the steel of cementation is merely a mixture of iron and carbone.
4. That steel which is over-cemented is an iron containing too large a quantity of carbone.
5. That iron would be a very soft metal, if it were not mixed with a greater or less quantity of oxigene and carbone.

Forged iron is distinguished into soft iron, and eager or brittle iron, by us (the French) called *Rouvrain*. This last has a coarser grain than the other: it is divided into red short iron, and cold short iron. The cause of this phenomenon is known: it arises from a phosphate of iron, which was discovered by Bergmann. This celebrated chemist constantly observed a precipitate to be formed in the solutions of cold short iron in the sulphuric acid. It was a white powder, which he called *Siderite*, and at first supposed to be a peculiar metal; but Mr. Meyer of Stetin has proved that it is a true phosphate of iron,

Soft iron does not afford it. All the irons of Champagne afford about a dram, or gros, in the pound of iron.



In order to obtain siderite, it is necessary that the solution should be saturated by a gentle heat on the sand bath. If the solution be made too quickly, the siderite is then mixed with ochre, which alters its purity and whiteness.

A precipitate is formed, which takes place so much the more speedily, as the solution is more diluted with water each time after filtration. The precipitate is formed in the first three or four days; a second is obtained towards the sixth day; and that which afterwards falls down is mixed with ochre.

Siderite may likewise be obtained by dissolving iron in the nitric acid, and evaporation to dryness. The iron is oxidized by this first operation. More nitric acid being poured on this residue, dissolves only the siderite, without touching the oxide of iron. A second evaporation must then be made; and the residue must be diluted with water, to evaporate the last portions of nitric acid; and that which remains is siderite. It is soluble in the sulphuric, nitric, and muriatic acids, from which it may be precipitated by pouring into the solution as much alkali as is necessary to saturate the acid solvent. If the alkali be added in excess, ochre is then precipitated; and the result is a phosphate, and a salt arising from the union of the acid  
made



made use of and the alkali which has served for the precipitation.

The fixed and volatile alkalis, and lime water, decompose siderite. It is likewise decomposed by projecting it upon fused nitre.

When it has been precipitated by ammoniac, crystals may be obtained by evaporation, which when treated with powder of charcoal afford phosphorus. The ochreous precipitate affords iron by reduction; it is therefore a combination of the phosphoric acid and iron. Every solution of iron is precipitated in the form of siderite by the phosphoric acid.

The effect of the tempering of iron likewise deserves the attention of the chemist. I am of opinion that the hardness and brilliancy which iron acquires by this operation, arises from its integrant parts, which are separated by the heat, being kept and left at a certain distance from each other by the sudden cold, which drives out the heat, without bringing the constituent principles of the mass together. The iron is then more brittle, because the affinity of aggregation is less.

Iron is easily oxidized. A bar of iron which is heated a long time in the forge furnace, becomes oxidized at its surface; and the coatings of metal  
which



which pass to the state of oxide, are separated from the mass in the form of scales. The most degraded and the most altered metal, in the state when it is no longer attracted by the magnet, forms an oxide of a reddish brown colour, known by the name of Astringent Saffron of Mars, or the Brown Oxide of Iron.

The colour of this oxide varies according to its degree of oxidation. It is yellow, poppy-colour, or red; and is easily reduced into a black powder, when heated with coaly matters.

The combined action of air and water constitutes a martial oxide, known by the name of Aperitive Saffron of Mars. This composition is produced by the combination of oxygenous gas and carbonic gas with the iron. The exposition of the iron to a humid atmosphere rusts it speedily, and causes it to pass to the state of aperitive saffron of Mars. This preparation is a true carbonate of iron.

Water likewise acts upon iron. If iron filings be put into this liquid, and be agitated from time to time, the iron becomes divided, and blackens; and by decanting the turbid water, a black powder is deposited, which is called the Martial *Æthiops* of Lemery, or the Black Oxide of Iron. It is a commencement of calcination



tion effected by the air contained in the water; but more especially by the decomposition of the water itself.

The fixed and volatile alkalis, in the fluid state, being digested upon iron, oxide a slight portion, which falls down in the form of æthiops.

All acids act more or less upon iron.

1. The concentrated sulphuric acid is decomposed by boiling upon this metal. If the mixture be distilled to dryness, the retort is found to contain sublimed sulphur, and a white mass, partly soluble in water, but incapable of crystallization.

But if the diluted sulphuric acid be poured upon iron, a considerable effervescence arises in consequence of the disengagement of hydrogenous gas. In this operation, the water is decomposed, its oxigene is employed to calcine the metal, while the hydrogen is disengaged; and the acid acts upon and dissolves the metal without being decomposed. This solution, when concentrated by evaporation, affords the sulphate of iron, which we have already treated of.

2. The nitric acid is decomposed rapidly upon iron. The solution is of a red brown colour, and suffers the oxide of iron to fall down at the  
expi-



expiration of a certain time. If new iron be plunged in this solution, the acid dissolves it, and lets fall the oxide which it held in solution.

If the solutions be concentrated, martial ochre of a red brown colour falls down. If the concentration be carried still further, a reddish jelly is formed, which is partially soluble in water.

Iron, precipitated from its solution by the carbonate of pot-ash, is easily dissolved by the superabundant alkali, and forms the martial alkaline tincture of Stahl.

Mr. Maret has proposed to precipitate the iron by the caustic alkali, to make the æthiops immediately. Mr. Darcet, in rendering an account of the process of Mr. Maret to the Royal Society of Medicine, has proposed that of Mr. Croharé, which consists in boiling upon the iron water acidulated with the muriatic acid.

Mr. de Fourcroy made a course of experiments upon the martial precipitates, which throws much light upon the causes of the astonishing varieties observed in them. He has proved that the whole depends either on the nature of the acid, or the manner of operating at the time of making these precipitates, or the quality of the precipitant.

3. The diluted muriatic acid attacks iron with vehemence. Hydrogenous gas is disengaged,



gaged, which arises from the decomposition of the water. If the solution be concentrated, and left to cool when it is of the thickness of syrup, a magma is formed; thin, flattened crystals are perceived, which are very deliquescent. The muriate of iron, distilled in a retort by the Duke d'Ayen, exhibited very singular phenomena. The first product was an acid phlegm. At a stronger heat, a non-deliquescent muriate of iron sublimed, at the same time that very transparent crystals rose to the roof of the retort, in the form of the blades of razors, which decomposed the light in the same manner as the best prisms. At the bottom of the retort there remained a styptic deliquescent salt, of a brilliant colour, and a foliated appearance, which exactly resembled the large plated talc, improperly called Muscovy Glass. This last salt, exposed to a violent heat, afforded a sublimate more astonishing than the former products. It was an opaque substance, truly metallic, which exhibited sections of hexahedral prisms, polished like steel. It was iron reduced, and sublimed.

4. It was long since known that iron is precipitated from its solutions by vegetable astringent substances; and the black dyes, and the fabrication of ink, are founded on this known fact.



fact. But it was not till lately that an acid has been proved to exist in these substances, which combined with the iron, and which may be obtained from all these astringent vegetables, either by simple distillation, or by mere digestion in cold water. The most simple process is the following :

Infuse one pound of powder of nut-galls in  $2\frac{3}{4}$  pints of pure water. Leave the mixture together for four days, frequently shaking the infusion. Then filter, and leave the fluid in a vessel simply covered with blotting paper. The liquid becomes covered with a thick pellicle of mouldiness, and a precipitate falls down in proportion as the infusion evaporates. These precipitates collected, and dissolved in boiling water, form a liquor of a brown yellow colour, which, evaporated by a gentle heat, deposits—  
1. A precipitate which resembles fine sand.  
2. Crystals disposed in the form of a star. This salt is grey; and it is impossible to obtain it of a whiter colour by any repetition of solutions and crystallizations.

It is an acid which effervesces with chalk, and reddens the infusion of turnsole.

Half an ounce of this salt is soluble in an ounce and a half of boiling water, or twelve ounces of cold water.



Boiling spirit of wine dissolves its own weight of this acid; but cold spirit dissolves only one-fourth.

This salt is inflammable in the fire. It melts, and leaves a coal of difficult incineration.

When this acid is distilled in a retort, it becomes at first fluid, gives out an acid phlegm, but no oil; and, towards the end, a white sublimate rises, which attaches itself to the neck of the retort, and remains fluid as long as it is hot, but afterwards crystallizes. Much coal is found in the retort. The sublimate has nearly the taste and smell of acid of benzoin, is as soluble in water as in spirit of wine, reddens the infusion of turnsole, and precipitates metallic solutions with their different colours, and iron black.

The solution of the salt of the nut-gall, poured into a solution of gold, renders it of a dark green; and precipitates a brown powder, which is gold revived.

The solution of silver becomes brown; and at length deposits a grey powder, which is revived silver.

The solution of mercury is precipitated of a yellow orange colour.

The solution of copper affords a brown precipitate.

The solution of iron becomes black.

The



The solution of the acetite of lead is precipitated white.

This salt is changed into the oxalic acid, if the nitric acid be distilled from it.

The basis of ink consists of a solution of iron by the gallic acid. To make good ink, take one pound of nut-galls, six ounces of gum arabic, and six ounces of green copperas, with four pints of common water. The nut-galls must be bruised, and infused for four hours without boiling. The pounded gum must be first added, and suffered to dissolve; and, lastly, the copperas, which immediately converts the fluid to a black colour. Lewis, of the Royal Society of London, made many researches on this subject; but he always returns to the forementioned substances. Powdered sugar is sometimes added, to render the ink shining.

5. The vegetable acid likewise dissolves iron with facility. It is this which holds the metal suspended in vegetables; and it may be precipitated from wine in the form of æthiops, by the means of alkalis.

Cream of tartar, or the acidulous tartrate of pot-ash, likewise dissolves iron; and the various degrees of concentration of this solution forms the soluble martial tartar, the aperitive extract of Mars, and the balls of Nancy.



7. The solution of iron, by the oxalic acid, affords prismatic crystals of a greenish yellow colour, and a somewhat astringent taste, soluble in water, and efflorescing by heat.

8. Iron, dissolved by the prussic acid, forms Prussian blue, or the prussiate of iron.

A singular mistake gave rise to the discovery of this substance. Diesbach, a chemist of Berlin, being desirous of precipitating a decoction of cochineal with fixed alkali, borrowed of Dippel an alkali upon which he had several times distilled animal oil; and as the decoction of the cochineal contained sulphate of iron, the liquor immediately afforded a beautiful blue. The experiment being repeated, was followed with similar results; and this colour became an object of commerce, under the name of Prussian Blue.

Prussian blue was announced in the *Memoirs* of the Academy of Berlin in the year 1710, but without any account of the process, which was kept a secret until other chemists discovered it. The process was rendered public in the year 1724, in the *Philosophical Transactions*, by Woodward; who declared that he had received it from one of his friends in Germany.

To make Prussian blue, four ounces of alkali are mixed with the same weight of dried bul-



locks blood, and the mixture exposed in a crucible, which is covered in order to stifle the flame; the fire is kept up until the mixture is converted into a red-hot coal. This charcoal is thrown into water, which is afterwards filtered, and concentrated by evaporation. The liquor is known by the name of the Phlogisticated Alkali. On the other hand, two ounces of the sulphate of iron and four ounces of the sulphate of alumine are dissolved in a pint of water. The two solutions are mixed, and a blueish deposition falls down, which is rendered still more intensely blue by washing it with muriatic acid.

Such is the process used in chemical laboratories; but in the works in the large way another method is followed. Equal parts of the raspings of horns, clippings of skins, or other animal substances, are taken and converted into charcoal. Ten pounds of this coal are mixed with thirty pounds of pot-ash, and the mixture is calcined in an iron vessel. After twelve hours ignition, the mixture acquires the form of a soft paste, which is poured out into vessels of water. The water is then filtered; and the solution mixed with another, consisting of three parts of alum, and one of sulphate of iron.

I have likewise made Prussian blue by calcining and burning in the same vessel equal parts



parts of the shavings of horns and tartar. I received the animal oil and the ammoniac, afforded by the calcination of these substances, in large casks, which communicated with each other, and formed an apparatus after the manner of Woulfe.

It has likewise been observed that the tips of thyme, the sun-flower, and several other vegetable substances, when treated with alkali, communicate to it, in a certain degree, the property of precipitating iron of a blue colour.

Much reasoning has been exhibited on the etiology of this phenomenon. Messrs. Brown and Geoffroy considered Prussian blue as the phlogiston of iron, developed in the lixivium of blood. The abbé Menon imagined that the colour of iron was blue; and that the phlogisticated alkali precipitated it in its natural colour.

Mr. Macquer refuted the opinion of his predecessors in the year 1752; and proposed a system, in which he considers Prussian blue as iron supersaturated with phlogiston. This skilful chemist proved that the blue is not soluble in any respect in acids; and that the alkalis are capable of dissolving the colouring matter of the Prussian blue, and of becoming saturated with it to such a degree as to be no longer capable of effervescing.



Mr. Sage affirmed that the iron was saturated with the phosphoric acid; and the celebrated Bergmann likewise suspected the existence of some animal acid, as is proved by his notes on the lessons of chemistry of Scheffer. But it was reserved to the celebrated Scheele to convert these suspicions into certainty.

He has proved that the lixivium of blood, exposed for a certain time to the air, loses the property of precipitating iron of a blue colour; and he has shewn that this circumstance depends on the carbonic acid of the atmosphere, which disengages the colouring part. By adding a small quantity of sulphate of iron to this lixivium, it is no longer changed in consequence of its remaining in the carbonic acid. By boiling this lixivium upon an oxide of iron, it is likewise no longer capable of change in the carbonic acid. The iron has therefore the property of fixing and retaining the colouring principle; but it is necessary that it should not be in the state of oxide.

Prussian blue, treated in the way of distillation with the sulphuric acid, permits a fluid to escape that holds the prussic acid in solution, which may be precipitated upon iron.

The processes of Scheele, to obtain this acid in a state of purity, consist in putting two ounces  
of



of pulverized Prussian blue into a glass cucurbit, with one ounce of red precipitate, and six ounces of water. This mixture is to be boiled for some minutes, continually stirring it. It then assumes a yellow colour inclining to green. The fluid being filtered, two ounces of boiling water are to be thrown on the residue. This liquor is a prussiate of mercury, which cannot be decomposed either by alkalis or acids. The solution is then poured into a bottle, in which an ounce of newly-made filings of iron is put: three gros of concentrated sulphuric acid are to be added, and the whole agitated strongly for several minutes. The mixture becomes perfectly black by the reduction of the mercury; the liquor loses its mercurial taste, and exhibits that of the colouring lixivium. After suffering it to stand at rest for a time, it is decanted, put into a retort, and distilled by a gentle fire. The colouring principle passes first, because more volatile than water. The operation must be put an end to, as soon as one quarter of the liquor has passed over. As this product contains a small quantity of sulphuric acid, it may be cleared of it by re-distilling it from pulverized chalk by a very gentle fire. The prussic acid then comes over in a state of the greatest purity. Scheele recommends that the vessels be well



luted, because the acid would otherwise escape, on account of its great levity. It is even of advantage to put a small quantity of water into the receivers, to absorb the acid; and it would likewise be very proper to surround them with pounded ice.

This acid has a particular smell, which is not disagreeable; and its taste is sweet.

It does not redden blue paper; but renders the solutions of soap and of the sulphure of alkali turbid. Mr. Westrumb pretends that the prussic acid is the same as the phosphoric; for he obtained siderite from Prussian blue, and formed animal earth by mixing the lixivium of blood with a solution of calcareous earth.

The solution of iron in the prussic acid affords Prussian blue. We are indebted to Mr. Berthollet for a very interesting series of experiments upon the prussic acid, and its combinations.

The oxide of iron is capable of existing in two different states in combination with the prussic acid. If the oxide predominates, the combination is yellowish; but if its proportion be less, the product is Prussian blue. All the acids are capable of dissolving the portion or surplus of oxide which constitutes the difference between the first and second combination.

The



The prussiate of pot-ash contains oxide of iron. If an acid be poured in, this oxide is dissolved, and is precipitated by double affinity in the form of Prussian blue. The prussiate of pot-ash made by a gentle heat, afterwards evaporated to dryness, then re-dissolved, and filtered, no longer affords the blue upon the addition of acids. It crystallizes in square plates with their edges cut slantways, forming octahedrons, whose two opposite pyramids are truncated. This solution of the prussiate of pot-ash, when mixed with the sulphuric acid, deposits Prussian blue, if it be exposed to the solar light, or to a strong heat. In these processes the prussiate of alkali may be entirely decomposed; the prussiate of iron, when precipitated by the action of the alkaline prussiate, carries down with it a notable proportion of alkali, of which it may be cleared by washings, which contain the alkaline prussiate. It is the same with regard to precipitations by the prussiates of lime and ammoniac.

The prussiate of mercury crystallizes in tetrahedral prisms, terminating in quadrangular pyramids, whose planes answer to the angles of the prisms. Iron in its metallic state decomposes the prussiate of mercury, and deprives it both of its oxigene and its acid. The oxide of mercury likewise decomposes the prussiate of iron, and



seizes its acid. The prussiate of mercury is but imperfectly decomposed by the sulphuric and muriatic acids. These acids form trifules, or triple salts, with it. The precipitate of the nitrate of barytes by the prussic acid, is not the compound which Bergmann supposed it to be, but is merely a trifule.

The prussic acid readily precipitates alumine from its nitric solution; the alumine nevertheless yields its prussic acid to iron.

The oxygenated muriatic acid, when mixed with the prussic acid, is again converted to the state of common muriatic acid: the prussic acid assumes a more lively smell, becomes more volatile, is deprived of its affinity to alkalis and lime; it precipitates iron of a green colour; and the green becomes blue if the precipitates be exposed to light, or if it be treated with the sulphureous acid.

The prussic acid, impregnated with the oxygenated muriatic acid, and exposed to light, assumes the smell of an aromatic oil, is collected at the bottom of the water in the form of an oil which is not inflammable, and rises in vapour by a gentle heat. By repeating this process it may be totally decomposed; and then this species of oil becomes concrete, and is reduced into crystals.

The



The acid appears to have undergone a partial combustion in this operation; at least the light and the sulphureous acid do not restore it but by depriving it of oxigene. The oxigenated prussic acid, mixed with lime or a fixed alkali, becomes totally decomposed. Volatile alkali is disengaged; and if the alkali was very caustic, such as the alcohol of pot-ash, it becomes effervescent.

The prussic acid of Scheele is only decomposed in part by this process; whence Mr. Berthollet concludes that it is composed of hydrogen, nitrogen, and carbone.

These experiments do not prove that oxigene exists in this acid. The water affords that which enters into the carbonic acid, produced by the distillation of the prussic acid. Prussian blue takes fire more easily than sulphur, and detonates strongly with the oxigenated muriate of pot-ash. The prussiate of mercury detonates still more strongly with the nitrate of mercury. The gas of these detonations has not yet been collected. The prussic acid, combined with alkali and the oxide of iron, cannot be separated by any acid without intervention of heat or light; and when it is disengaged, it is no longer capable of separating iron from the weakest acid, unless it be in the way of double affinity. Mr. Ber-



Berthollet thinks that the elastic state of this acid diminishes this affinity; and that it is necessary, in order that it may easily enter into combination, that it should have lost some of its specific heat. It is this which renders the oxygenated acid so feeble.

Prussian blue afforded me, by distillation, in the ounce, one gros twenty-four grains of ammoniac, thirty-six grains of the carbonate of ammoniac, four gros twelve grains of oxide of iron, or alumine, and one hundred and sixty-four inches of hydrogenous gas burning with a blue flame.

The ammoniac comes over in combination with a small quantity of the colouring principle, which it takes up, and holds in solution: the sulphuric acid renders this visible.

Ammoniac heated upon Prussian blue decomposes it, by seizing the colouring matter.

Lime-water digested upon Prussian blue dissolves the colouring principle by the assistance of a gentle heat; the combination is rapid, and the water acquires a yellow colour. By filtration, the liquor passes of a fine bright yellow, no longer converts syrup of violets to a green, and is no longer precipitated by the carbonic acid. It appears to be completely neutralized, and affords an exceedingly fine blue, when  
poured



poured into a solution of the sulphate of iron. The prussiate of lime has been proposed, by Messrs. Fourcroy and Scheele, as the most accurate means of ascertaining the presence of iron in any mineral water.

The pure fixed alkalis immediately discolour Prussian blue in the cold. This combination produces heat; and the pure alkalis ought to be preferred to the carbonates of alkali in experiments of this nature.

Magnesia likewise seizes the colouring matter of Prussian blue; but much more weakly than lime-water.

A mixture of equal parts of steel filings and nitrate of pot-ash, thrown into a crucible strongly ignited, detonates at the end of a certain time, with the disengagement of a considerable quantity of very bright sparks. The residue, when washed and filtered, affords an oxide of iron of a yellowish colour, known by the name of Zwelfer's Saffron of Mars.

Iron decomposes the muriate of ammoniac very well. Two gros of steel filings, and one gros of this salt, afforded Mr. Bucquet, by distillation in the pneumato-chemical apparatus over mercury, fifty-four cubic inches of an aëri-form fluid; half of which was alkaline gas, and the other half hydrogenous gas.

This



This decomposition is founded on the strong action of the muriatic acid on iron.

One pound of the muriate of ammoniac in powder, and one ounce of steel filings, sublimed together, form the martial flowers, or *Ens Martis*. These flowers consist merely of the muriate of ammoniac, coloured, and rendered yellow by an oxide of iron.

The oxide of iron decomposes the muriate of ammoniac much better. This is an effect of double affinity. The ammoniac which rises is sometimes effervescent.

A mixture of good filings of steel and sulphur, moistened with a small quantity of water, becomes heated in the course of several hours. The water is decomposed, the iron rusts, the sulphur is converted into acid, the hydrogenous gas of the water exhales, and the heat is sometimes sufficient to set the mixture on fire. This phenomenon constitutes the volcano of Lemery.

There is the strongest analogy both in the phenomena and effects of the inflammation of this volcano, and the decomposition of pyrites.

Sulphur combines easily with iron by fusion, and then forms a true martial pyrites.

Iron may be alloyed with several metallic  
sub-



substances; but the only alloy which is used in the arts is that which it contracts with tin, to form white iron, or tin plates.

To form the tin plates (commonly known by the name of Tin in England), the softest iron is chosen, which is reduced into very thin plates. Care is taken to polish or clean the surface very well; and this is done in several ways. The pieces are rubbed with sand-stone, and afterwards kept for three times twenty-four hours in water, acidulated by the fermentation of malt, turning them from time to time. They are afterwards cleaned, dried, and are then ready for tinning. Sal ammoniac is likewise used in some manufactories. For this purpose the plates are disposed in a chamber, in which a certain quantity of sal ammoniac is volatilized. The salt forms a covering over the whole surface of every plate, and possesses the double advantage of clearing it from rust, and affording the coaly principle necessary to prevent the calcination of the metal.

When the iron is well cleared, the plates are plunged vertically into a bath of tin, whose surface is covered with pitch, or tallow. They are turned in the bath; and when taken out they are wiped with saw-dust, or bran.

The uses of iron are so very extensive, that  
there



there are few arts which can be practised without it. It is with justice considered as the soul of all the arts. Some of its ores are used in their native state ; such as the hæmatites, which is made into burnishers.

The sulphate of iron is the basis of all black colours, inks, &c.

The ochres are used by painters, under the name of Umber ; and the brown red has the most extended use. With us (in France) it is applied to give a colour to brick pavements, to paint our doors and windows, to smear our casks, and to secure them from decay and insects in sea voyages.

Cast iron is used to make boilers, chimney-grates, hearths, pots, &c. The instruments of agriculture are made of this metal : steel is used not only as steel ; but its hardness renders it proper to cut and work the other metals.

The magnetical property of iron has led to the discovery of the mariner's compass ; and this metal, if it were productive of no other advantage to mankind, would on that account be entitled to their greatest attention.

Prussian blue is an agreeable colour, greatly esteemed, and much used.

Iron likewise furnishes the art of medicine with remedies. It is the only metal which is  
not



not noxious; and it has such an analogy with our organs, that it appears to constitute one of the elements of the human frame. Its effects in general consist in strengthening the stomach; and it appears to possess the property of passing in the circulation under the form of æthiops. The valuable experiments of Mr. Menghini, published in the Memoirs of the Institute of Bologna, have proved that the blood of persons who take martial remedies is thicker, and contains more iron. Mr. Lorry observed that the urine of a sick person, to whom he administered iron in a state of extreme division, was manifestly coloured with the nut-gall.

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## C H A P. XI.

*Concerning Copper.*

**C**OPPER is a reddish metal, hard, elastic, sonorous, and affording a disagreeable smell by friction. Its taste is styptic, and nauseous. One cubic foot of copper weighs five hundred and forty-five pounds. The specific gravity



gravity of cast copper not hammered is 7,7885.  
—Briffon.

The alchemists distinguished this metal by the name of Venus, on account of the facility with which it unites and is alloyed with other metals.

It may be reduced into very thin leaves, and drawn into very fine wire. The tenacity of this metal is such, that a wire of one tenth of an inch in diameter is capable of supporting a weight of two hundred and ninety-nine pounds four ounces, without breaking.

This metal is capable of affecting a regular form. The abbé Mongez observed it in solid quadrangular pyramids, sometimes inserted into each other.

Copper is found in various forms in the bowels of the earth.

1. Native copper.—This copper exists sometimes in leaves in a gangue of quartz. It is likewise found in compact masses at Japan. There is one of these pieces in the royal cabinet, which weighs ten or twelve pounds.

Native copper is usually disseminated in a brownish martial earth, susceptible of a polish. When this ore is rubbed with a flint, the traces appear of a beautiful copper-colour. Ores of this kind are found at Kaumisdorf in Thuringia.  
—Sage, *Analyse Chimique*, t. iii. p. 205.



We have likewise found native copper at Saint Sauveur. It has the form of nodules resembling stalactites. Most of the native coppers appear to be formed by cementation, or by the precipitation of this metal dissolved in an acid, and thrown down by martial salts.

Mr. Sage thinks that this metal may likewise be precipitated from its solutions by phosphorus. To effect, says he, the precipitation of copper by phosphorus, twelve grains of this metal are to be dissolved in half a gros of nitric acid. The solution must be poured into half a pint of distilled water, into which a cylinder of phosphorus, two inches long, weighing forty-eight grains, must be plunged. The surface becomes almost immediately black, and is covered with particles of copper possessing the metallic colour and brilliancy. At the end of several days, octahedral crystals are seen, whose insertions into each other produce elegant dendrites; and at the end of ten days the twelve grains of copper are completely reduced, as is proved by pouring ammoniac into the water. If it do not exhibit a blue colour, it is proof that the fluid contains no copper.

2. Copper mineralized by sulphur forms the yellow ore of copper.

This ore is of a golden colour, and the ig-



norant are often deceived by its flattering appearance. It contains a larger quantity of copper in proportion as the sulphur is less in quantity, and gives fewer sparks with the steel. It sometimes crystallizes in beautiful octahedrons. I possess two specimens covered over with trihedral pyramids of near an inch long, and between four and five lines in diameter at the bases.

When the sulphur is so abundant that the proportion of copper will no longer pay for the working, the ore is called Marcasite. The marcasite crystallizes in cubes or in octahedrons, which easily effloresce.

The yellow copper ore is found in various states, according to the course of its decomposition. The first impression of hepatic vapours colours the surface in a thousand shades, in which state it is known by the name of Peacocks Tail, Pigeons Neck, &c.

The last degree of alteration of this ore, effected by the simple disengagement of sulphur, forms the hepatic copper ore. The yellow colour is then converted into an obscure brown colour: this ore appears then to contain no other principles but water, copper, and iron, which last is always more or less abundant in these ores.



The yellow copper ore sometimes forms sulphate of copper in its decomposition. This salt is dissolved in water, and forms springs more or less loaded with it, from which the copper may be obtained by cementation. Old iron is thrown into the water; the copper is precipitated, and the iron takes its place. In this way it is obtained in Hungary, and we might use this æconomical process in several parts of our province. I have stalactites in my collection, sent me from Cevennes, which are coloured blue by a very considerable quantity of copper. In Gevaudan, at half a quarter of a league from St. Leger de Peyre, several springs of water impregnated with copper are found, which run into a valley. The inhabitants of this canton drink a glass of the water occasionally as a purgative.

The skeletons of animals are sometimes found in copper-mines penetrated with that metal. Swedenburg has given an engraving of the figure of the skeleton of a quadruped taken out of a copper-mine, and coloured by that metal. In the royal cabinet there is a human hand, green at the extremity of the fingers, the muscles of which are dried, and greenish. According to the report of Mr. Leyer, consul of mines, there was found at Fahlun in Sweden, in the great cop-



per-mine, a human carcase, which had remained there forty years, with the flesh and bones entire, without corruption, and without emitting any smell. The body was clothed, and entirely incruusted with vitriol.—*Acta Literaria Succ. tri. i. anno 1722, p. 250.*

The turquoise stones are merely bones coloured by the oxides of copper. Mr. De Reaumur, in the year 1725, gave an account to the Academy of the turquoises found in Lower Languedoc. The colour of the turquoise frequently becomes converted into green, which depends on the alteration of the metallic oxide. The turquoise of Lower Languedoc emits a fetid smell by the action of fire, and is decomposed by acids. The turquoise of Prussia emits no smell, and is not attacked by acids. Mr. Sage suspected that the osseous part is agatized in these last.

3. Grey copper ore.—The copper is mineralized by arsenic. It has a grey colour, and an appearance nearly vitreous. It usually contains silver; and, when wrought to extract this precious metal, it is called the Grey Silver Ore. It affects a tetrahedral form; and arsenic is the most predominant of its principles.

4. The grey antimonial copper ore.—This differs from the former, because it contains sul-



phur and antimony, and is much more difficult to be wrought. When exposed to the fire, it becomes as fluid as water; the sulphur is volatilized with the antimony and the arsenic. The residue of the torrefaction is a mixture of the antimony and copper, and sometimes it contains silver likewise.

5. Copper ores, in their decomposition, are reduced to a more or less perfect state of oxidation. The carbonic acid frequently unites to the metal, and becomes the mineralizer. This substance is known by the name of Mountain Blue, Azure of Copper, Mountain Green, Malachite.

A. The azure of copper crystallizes in rhomboidal tetrahedral prisms, rather flattened, terminating in dihedral summits: these crystals are of the most beautiful blue; they are frequently altered by exposure to the air, and become converted into malachite.

Mr. Sage has imitated the azure, both in the form and colour, by dissolving copper, in the cold, in water saturated with carbonate of ammoniac. When the azure of copper is of a less brilliant colour, and in the pulverulent form, it is called Mountain Blue.

B. The malachite, crystallized in octahedrons, has been found in Siberia. This ore is frequently striated, formed into small tufts of



a silky appearance, or in very close parallel fibres. The malachite is frequently covered with protuberances. This figure appears to announce that it has been formed in the same manner as the stalactites.

Mountain green differs from the malachite only in its pulverulent form, and the mixtures which alter it. The alterations of the copper ores, and native copper likewise, produce a cupreous oxide, which bears the name of Red Copper Ore. The mine of Predanah, in the county of Cornwall, has afforded the finest specimens of red copper ore. The metal is nearly in the metallic state, and has the form of octahedral crystals. The granular red copper ore differs from this only in its figure. It sometimes has a brown martial earth for its gangue.

The azure, the malachite, and the red copper require no other process but mere fusion with coal to convert them into metal; the other kinds require to be cleared of their mineralizer by torrefaction, and afterwards to be fused with three parts of black flux.

To assay a sulphureous copper ore, Mr. Exchaquet proposes to take two gros of the crude ore, and one of the nitrate of pot-ash; which, after pulverization, are to be detonated in an ignited crucible. The matter becomes hard after the detonation;



detonation; upon which the fire is to be increased and kept up, in order that the sulphur may be dissipated. The fire is then to be still more strongly urged, until the ore enters into fusion; and a mixture of half an ounce of tartar, one quarter of an ounce of salt, and a small quantity of charcoal, is to be added in equal portions. An effervescence takes place at each projection of the mixture. The fire is then to be still more strongly raised, and the crucible covered, and kept in this state for half an hour, in order that the copper may flow into a mass. In this way a very malleable button of copper is obtained.

The working of copper ores varies according to their composition. But, as the sulphureous ores are most commonly wrought, we shall confine ourselves to the process which is most suitable to their nature.

The metal is first picked or sorted; afterwards pounded in a mill, and washed, to separate the gangue, and other foreign substances; it is then roasted, to drive off its mineralizer; and afterwards fused in the blast furnace. The result of this first fusion is black copper; which is again fused in the refining furnace, to dissipate all the sulphur which has withstood the preceding operations. When it is very pure, it is



poured into a broad vessel, or test; a small quantity of water is thrown on its surface, which, being by that means cooled, separates from the rest, and is taken up. This is the copper in rosettes, which is taken to the hammer to be beat into proper form. The several operations are different in various places. In some countries, the ore is roasted as often as eight times; in others, one or two are sufficient; and in some places it is not roasted at all. This variety depends—  
1. On the variations of practice: those who roast but little, employ more time and care in the fusion and refining. 2. On the nature of the ore: when it is rich in iron, the roastings are necessary to dispose this metal to fusion.

The method of roasting is likewise prodigiously varied. Pieces of the mineral are sometimes heaped up on a bed of combustible matter, and in this manner the calcination is performed; but, when this ore abounds with sulphur, it may be extracted by the ingenious process used at St. Bell, and described by Messrs. Jars in their excellent work.

The fusion is commonly performed in the blast furnace; but at Bristol, in England, the ore is roasted in a reverberatory furnace, and fused into black copper.

The refining furnace constructed at St. Bell,  
by



by Messrs. Jars, appears to me to be one of the best. They have published an excellent description of it, which may be consulted in their *Mineralogical Travels*. The refining of copper consists in depriving it of the sulphur and iron which it may still retain. The sulphur is dissipated by fire, and bellows properly directed; and the iron is scorified by the assistance of some pounds of lead fused with the copper. The skilful mineralogists whom I have just quoted, make use of a reverberatory furnace, lined with charcoal; and fuse and scum their copper, without using lead.

When the copper contains a sufficient quantity of silver to admit of extraction, the following process is used:—1. Seventy-five pounds of copper are fused with two hundred and seventy-five of lead. The alloy is cast into flat pieces, which are called *Loaves of Liquation*. 2. These loaves are exposed to a heat sufficient to fuse the lead, which carries the silver with it, and leaves the copper, which, on account of its being more difficult to fuse, retains the original form of the loaves; and is every where penetrated by the interstices through which the fused metal made its escape; these are called *Dried Loaves of Liquation*. 3. They are carried into a second furnace, where they are exposed  
to



to a stronger heat, to deprive them of the small quantity of lead which they still retain. 4. The lead is afterwards taken to the cupel, where it is fused, and separated from all the silver it had taken up.

Copper is altered by long exposure to the air. Its surface becomes covered with a greenish coating, which is very hard, and known to the antiquarians under the name of Patin. This is the seal which attests the antiquity of statues and models covered with it.

Copper, exposed to the fire, becomes blue, yellow, and at last violet. It does not flow until it is strongly ignited. When in contact with the coals, it gives a blue greenish tinge to the flame; and, if it be kept a long time in fusion, part of it is volatilized.

When copper is heated in contact with air, it burns at its surface, and becomes changed into a blackish red oxide. This oxide may be separated by striking the plate which has been ignited, or by plunging it in water. When the oxide has been pounded, and more strongly calcined, it assumes a brown red colour, and may be converted into a glass of a brown colour by a more violent heat.

1. The sulphuric acid only acts on copper when concentrated, and very hot. It then dissolves



dissolves it, and easily affords blue crystals of a rhomboidal form. The sulphate of copper is known in commerce by the name of Blue Vitriol, Cyprian Vitriol, Blue Copper, &c.

Two methods are used to make the sulphate of copper which is met with in commerce. The first consists in calcining the cupreous pyrites, and causing them to effloresce, in order to develop the salt, which is then extracted by lixiviation. The second consists in forming this pyrites artificially, burning it, and lixiviating it, to extract the salt.

This salt possesses a very strong styptic taste. It is easily fusible by heat, which dissipates its water of crystallization, and changes its colour to a blueish white. The sulphuric acid may be extracted by a very strong fire. Lime and magnesia decompose this salt; and the precipitate is of a blueish white colour. If it be dried in the open air, it becomes green. Ammoniac likewise precipitates the copper in a whitish blue: but the precipitate is dissolved nearly at the same instant that it is formed; and the result is a solution of a beautiful blue colour, known by the name of Aqua Celestis.

This salt contains in the quintal thirty pounds acid, forty-three water, and twenty-seven copper.

2. The nitric acid attacks copper with effervescence,



vescence, at the same time that it becomes decomposed, and emits abundance of nitrous gas. When it is proposed to obtain this gas by the action of the acid upon the copper, it is necessary to have the precaution of weakening the acid, and to present the copper in pieces of considerable magnitude. If these circumstances be not attended to, the acid attacks the metal with such violence, as suddenly to emit a prodigious quantity of gas; immediately after which an absorption takes place, and the water of the jar passes into the bottle. In this case ammoniac is formed. The diluted nitric acid perfectly dissolves copper: the solution is blue. If it be speedily concentrated, no other result is obtained but a magma without crystals; but if it be left exposed to the air, it affords crystals in long parallelograms. By leaving a solution of this kind to spontaneous evaporation, I have obtained rhomboidal crystals, which, instead of being blue, as they are usually described, are white. They decrepitate upon the coals, emit a red gas by mere heat, and nothing remains but a grey oxide.

3. The muriatic acid does not dissolve copper unless it be boiling and concentrated; the solution is green, and affords prismatic crystals of considerable regularity when the evaporation



tion is slow. This muriate is of an agreeable grass-green colour; its taste is caustic, and very astringent: it fuses by a gentle heat, and congeals into a mass; in which the acid is so adherent, that a very strong fire is required to disengage it. It is very deliquescent. Ammoniac does not dissolve the oxide of this muriate with the same facility as it does that of the other cupreous salts. This observation was made by Mr. De Fourcroy; which I think may be explained from the circumstance that the muriatic acid suffers the copper to be precipitated in the metallic form, instead of giving out a portion of its oxigene, which would facilitate the action of the alkali.

4. The acetous acid, when made to act either hot or cold upon copper, only corrodes it, and produces the substance known in commerce by the name of Verdigris. The verdigris which is most used in the arts has been long fabricated at Montpellier exclusively. The prejudice which prevailed, that the cellars of this city alone were proper for this operation, preserved this commerce till lately in its hands. But the progress of information has successively put it in the power of other countries to partake in this manufacture.

The process used at Montpellier consists in fermenting



fermenting the refuse of grapes with four wine\*. This refuse is afterwards laid in alternate strata, with plates of copper six inches long and five broad. In this state they are left for a certain time; after which they are taken out, and placed edgewise in a cellar, where they are sprinkled with four wine: in this situation the verdigris swells up; and is afterwards scraped off, put into sacks of leather, and exported to foreign countries.

Ready-made vinegar is used at Grenoble, and the plates of copper are sprinkled with it.

The verdet or verdigris of Grenoble contains one-sixth less of copper: the vinegar which is obtained is stronger and more abundant. It has not the empyreumatic smell of that of Montpellier. The copper is therefore partly dissolved in the verdet of Grenoble; because it has been first reduced into an oxide by the impression of the vinegar, and afterwards attacked by the subsequent affusion of the same acid. It is therefore an acetate of copper.

The oxides of copper, dissolved in vinegar, form a salt known by the name of Crystallized Verdigris, Crystals of Venus, Acetate of Copper.

\* Vinasse.



To obtain this salt, the vinasse or four wine is distilled; and this weak vinegar boiled on the verdigris. The solution is then conveyed into a boiler, where it is concentrated until a pellicle appears. Sticks are then plunged in the bath; and at the end of a certain number of days the sticks are again taken out, covered with rhomboidal crystals of a blue colour. These clusters of crystals, weighing each from four to six pounds, are wrapped up in paper, and distributed for sale.

The vinegar may be disengaged by distillation from these crystals; and the residue is a cupreous oxide, which possesses the characters of pyrophorus.

Vinegar, distilled on manganese, dissolves copper; which proves that it has taken up oxygen. The acetic acid, or radical vinegar, differs from ordinary vinegar, in containing a greater quantity of oxygen; and it is this oxygen which renders it proper to dissolve copper in the metallic state. The acetate of copper may likewise be formed by decomposing salt of Saturn, or sugar of lead, by the sulphate of copper. The sulphate of lead falls down; and the solution, when concentrated, affords the cupreous acetate.

5. The pure fixed alkalis, digested in the



cold with filings of copper, become of a blue colour; but ammoniac dissolves it much more speedily. I put copper filings into a bottle with very caustic ammoniac, and kept the bottle stopped for two years; the copper was deprived of its colour, and became similar in appearance to a grey clay: whereas a similar vessel, in which I had placed the same mixture, but left open, soon afforded me very small blue crystals; and the whole concluded by affording only a hard stratum of green matter, resembling malachite.

Copper is precipitated from its solutions by iron. For this purpose nothing more is required than to leave the iron in one of the solutions of the other metal, which need not be strong. The phenomenon may be rendered very surprising, by pouring the solution of the sulphate of copper upon the clean surface of a piece of iron; for this surface instantly becomes covered with copper. The copper obtained by this means is known by the name of Copper of Cementation.

This precipitation of one metal by another, has given rise to a belief that the iron was converted into copper: and I could, from my own knowledge, mention the names of individuals who have been imposed on by this phenomenon.



Copper mixes with most of the metals; and forms—

1. With arsenic, the white tombac.
2. With bismuth, an alloy of a reddish white colour, with cubic facets.
3. With antimony, a violet-coloured alloy.
4. It may be combined with zinc by fusion, or by cementation with lapis calaminaris. By the first process, similor, or the Manheim gold, is obtained; the produce of the second is brass.
5. Copper, plunged in a solution of mercury, assumes a white colour, which arises from the mercury which is displaced by the copper.
6. Copper is easily united with tin; and on this depends the art of tinning: for which purpose it is necessary to clean the surface of the metal perfectly; because the oxides do not combine with the metals. This first object is accomplished by rubbing the metal intended to be tinned with the muriate of ammoniac, or by scraping it effectually; or even by passing a weak acid over its whole surface. After this operation the tin is applied by fusing it in the vessel intended to be tinned, then spreading it about with old rags rolled up; and the oxidation of these metals is prevented by means of pitch.

Copper, fused with tin, forms bronze, or bell-metal.



metal. This alloy is more brittle, whiter, and more sonorous, in proportion to the quantity of tin which enters into its combination : it is then used to make bells. When it is intended to be applied to the purpose of casting statues, or forming great guns, a larger proportion of copper is used ; because in this case solidity is one of the first requisites.

7. Copper and iron contract very little union.

8. Copper, alloyed with silver, renders it more fusible ; and these two metals are combined to form solder. Hence it is that verdigris is occasionally observed in pieces of silver, at those parts where joinings have been made by means of solder.

Copper precipitates silver from its solution in the nitric acid. This method is used in the mints, to separate the silver from the acid, after the operation of parting.

Copper is very much used in the arts. All the boilers in dye-houses which are intended to contain compositions that do not attack this metal, are made of copper.

It is at present used as a sheathing for the bottoms of ships. All our kitchen utensils are made of it ; and, in spite of the danger to which we are daily exposed of being poisoned, and  
notwith-



notwithstanding the slow and destructive impression which this metal cannot but produce upon us individually, there are few houses from which this metal is yet banished. It is a desirable object that a law might be passed to prohibit its use amongst us; as has been done in Sweden, at the solicitation of the Baron De Schoffer, to whom the public gratitude has erected a statue of the same metal. It is an allowable infringement of personal liberty, when government take upon them to direct the conduct of individuals, in such a manner as to secure their own safety. There is no year passes in which several persons are not poisoned by hams, or other food which is suffered to remain in copper vessels.

Tinning is not a complete remedy against this danger; for it leaves an infinity of points where the copper is uncovered\*.

The sulphate of copper is very much used in dyeing. The crystals of Venus, and verdigris, are likewise used in painting; they enter into the composition of colours, varnishes, &c.

\* It may besides be doubted whether the extremely thin white coating, which conceals the internal surface of tinned copper, be not a kind of bell or speculum metal, instead of tin, as it is generally supposed to be. T.



The various alloys of copper with the metals, render it highly valuable in the arts. Brass, bronze, and bell metal, are very extensively useful.

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## C H A P. XII.

*Concerning Mercury.*

**M**ERCURY differs from all other metals, by its property of retaining the fluid state, at the ordinary temperature of the atmosphere.

It possesses the metallic opacity and brilliancy; and even acquires malleability, when deprived of fluidity by a proper degree of cold. The best ascertained experiment which has been made on this phenomenon, was performed by the Academy of Peterburgh, in 1759. The natural cold was increased by a mixture of snow and highly concentrated nitric acid; and the thermometer of De Lisle was caused to fall to 213 degrees, which corresponds with 46 be-



low 0 of Reaumur. At this period the mercury appeared to descend no lower : the bulb of the thermometer being then broken, the metal was found to be in a congealed state, and bore to be flattened by the hammer. Mr. Pallas congealed mercury, in 1772, at Krasnejark, by the natural cold : he then found that it resembled soft tin. It has been ascertained in England that the degree of its congelation was the 32d of Reaumur. Mr. Matthew Guthrie, consul at the court of the Empress of Russia, proved that the degree of cold of this congelation was 32 degrees below 0 of Reaumur ; and that, when the mercury is purified by antimony, it congeals at 2 degrees lower.—See the *Journal Encyclopédique*, September 1785\*.

Mercury is as indestructible by fire as gold and silver ; and its properties in general have caused it to be arranged among the perfect metals.

A cubic foot of this metal weighs 949 pounds ; and its specific gravity is 13,5681.—Briffon.

Mercury has been found in the earth in five different states.

1. Virgin Mercury is found in most of the

\* For an account of this subject, see Dr. Blagden's History of the Congelation of Mercury, in the seventy-third volume of the *Philosophical Transactions*.



mines of this metal. Heat alone, or mechanical division of the ore, is sufficient to exhibit it in the metallic form.

Native mercury has been found in digging the foundations of some houses at Montpellier; and this metal has been constantly mixed and confounded with a grey or red clay, which forms a bed almost continuous, at a few feet beneath the foundation of this town.

The observations which I have had occasion to make on this subject, have ascertained that the mercury exists in a stratum of decomposed grit-stone, very argillaceous, ferruginous, and ochreous; of a red, brown, or grey colour. In this clay, the globules of mercury, in considerable abundance, were easily distinguishable, lying upon greyish plates. Traces are perceived which resemble dendrites; and its impressions are formed by layers of the oxide of mercury.

Several pounds of mercury have likewise been found in a well at Vienne in Dauphiny; and Mr. Thouvenel has pointed out to us three mines of this metal in the single province of Dauphiny, according to the indications of Bleton.

2. Mr. Sage read to the Academy, on the 11th of May 1782, the analysis of an ore of mercury,



mercury, in the form of a solid oxide, which came from Idria in Friuli. It is of a brown red colour; and its fracture is granulated. It is reducible by mere heat; and affords oxygenated gas. It emits only half the quantity afforded by red precipitate; because this oxide contains metallic mercury. It affords ninety-one pounds of mercury per quintal, and a small quantity of silver.

3. The muriate of mercury, or corneous mercury, has been found native in the mine of Mufchel-Lamburg, in the duchy of Deux-Ponts. Mr. Sage obtained eighty-six pounds of mercury per quintal.

Mr. Woulfe has likewise discovered, in 1776, a very ponderous white, green, or yellow crystallized ore of mercury; in which he proved the existence of the sulphuric and muriatic acids.

4. Mercury is sometimes naturally amalgamated with other metals, such as gold, silver, arsenic, copper, &c.

5. Mercury is usually mineralized by sulphur; and the product is cinnabar or æthiops, according to the colour.

Cinnabar is found under different forms.

1. In red crystals, consisting of two triangular pyramids, truncated, and joined base to base,



or else separated by a very short intermediate prism. Cinnabar has likewise been found crystallized in transparent plates.

2. Cinnabar is almost always found in masses, more or less compact; the colour varies from deep black to the brightest red. In this last state it is distinguished by the name of Vermilion.

Cinnabar has for its gangue, quartz, clay, calcareous earth, ponderous spar, and even coal. The ore which the Germans called Brandertz, has for its gangue a bituminous matter, which burns perfectly well; and it affords only six pounds of mercury in the quintal.

The principal cinnabar mines which are wrought in Europe, are those of the Palatinate and those of Spain. Mr. Sage informed us, in 1776, of the process used in the Palatinate; and we are indebted to Mr. De Jussieu for a description of the method used in Spain.

In the Palatinate, the pounded and sifted ore is mixed with one-third of lime; and the mixture introduced into iron cucurbits, one inch thick, three feet nine inches long, one foot wide, with an opening of five inches. These vessels are disposed in a gallery. Forty-eight of these retorts being arranged in two parallel lines, a second row is placed above the first. To the neck of each cucurbit an earthen pot is adapted, which



which is one-third filled with water, and accurately luted on. The gallery is heated at the two extremities; several apertures formed in the dome serve the purpose of chimneys; and the distillation is effected by a fire kept up for ten or twelve hours.

This process was followed at Almaden till the year 1647, when the following was adopted, as being more simple and oeconomic. The furnace is twelve feet high, and four feet and a half diameter within. At the distance of five feet and a half from the ground, is an arch upon which the ore is disposed, and a fire is kindled in the ash-hole. The sublimed mercury escapes through twelve apertures formed in the upper part of the laboratory. To these apertures, rows of aludels, inserted one in the other, are adjusted, and disposed parallel upon a terrace, which terminates in a small building separated into as many chambers as there are files of aludels. Each chamber has a cavity in the middle, to receive the small quantity of mercury which may arrive to that distance.

Every furnace contains two hundred quintals of cinnabar, and the fire is kept up for three days. The sulphur which burns is disengaged in the form of sulphureous acid, and escapes through



through small chimneys made in each chamber. Every repetition of the process affords from twenty-five to sixty quintals of mercury.

The mine of Almaden has been wrought from time immemorial. Its veins are from three to fourteen feet in breadth; and their breadth is even larger where they join.

Hitherto no method has been discovered to fix mercury but that of extreme cold. This metallic substance, naturally fluid, is capable of rising even by a very moderate fire; as is proved by an experiment of Mr. Achard, who having left a dish containing twenty pounds of mercury over a furnace which was daily heated, experienced a salivation at the end of several days; as did likewise two other persons who had not quitted the chamber. He estimates this heat at about eighteen degrees of Reaumur.—*Journal de Physique*, October 1782.

It is dangerous to oppose the evaporation or dilatation of this metal which is produced by heat.

In the year 1732 an alchemist presented himself to Mr. Geoffroy, pretending he had discovered the means of fixing mercury. He inclosed the metal in an iron box, and this box in five others, which were placed in a furnace; the explosion was so strong, that it burst through the  
the



the boards of the floor. Mr. Hellot has related a similar fact to the Academy.

Mercury boils in the same manner as other liquids when it is heated; and for this purpose it does not even require a very considerable heat; the ebullition consists merely in its transition to the vaporous state; for it may be distilled like other fluids, and by that means cleared of its impurities. Boerhaave had the patience to distil the same mercury five hundred times successively; and the metal suffered no other change, than that it afforded a grey powder, which required only trituration to convert it again into running mercury.

Mercury is not easily changed in the air; but if the action of the air be assisted by heat, the mercury gradually loses its fluidity; and at the end of several months forms a red oxide, which alchemists have distinguished by the name of *Precipitate per se*. The apparatus made use of for this operation is a very large and very flat bottle, closed with a stopper, in which there is a capillary perforation. The mercury within the bottle by this means possesses the contact of air; and by disposing the apparatus upon a sand bath, and keeping up the state of ebullition in the fluid, the oxide may be obtained in the course of several months.

This



This oxide gives out its oxigene by simple heat, without any intermedium; and the mercury resumes its metallic form: one ounce affords about a pint. A quintal of mercury takes up about eight pounds of oxigene. The red oxide of mercury, exposed to heat, sublimes in close vessels, and may be converted into a very beautiful glass. I have observed this on all occasions when I have made the red oxide by means of the nitric acid, according to the process which I shall immediately describe.

It is certain that mercury upon which water is boiled, communicates a vermifuge property to that liquid, though the most accurate experiments of Lemery have shewn that the metal does not perceptibly lose weight; which proves that the principle taken up by the water is very fugacious, and so light that it does not constitute any sensible part of the weight. Water which has remained for a certain time over mercury contracts a very evident metallic taste.

1. The sulphuric acid does not act upon mercury unless assisted by heat. In this case, sulphureous gas is disengaged; and a white powder falls down, the quantity of which becomes greater in proportion as the acid is decomposed. This oxide weighs one third more than the mercury made use of. It is caustic: if hot water be poured



poured on it, it becomes yellow; and if it be urged by a violent heat, it affords oxigenous gas, and the mercury resumes its natural form. This yellow oxide, obtained by means of the sulphuric acid, is known by the name of Turbith Mineral. It has long been considered as a sulphate of mercury. Mr. Baumé has proved that it does not contain a particle of acid; and it appears that the water which develops its yellow colour, seizes the small quantity of undecomposed acid which was mixed with the oxide. If the water which has been poured on it be evaporated, a salt is obtained in small, soft, and deliquescent needles, which may be deprived of their acid by the simple affusion of water. This fluid precipitates the mercury from them in the form of turbith.

2. The nitric acid of commerce, at the strength of thirty-five degrees, dissolves mercury with violence, even without the assistance of heat. This solution is accompanied with the disengagement of a considerable quantity of nitrous gas; because it is necessary that the acid should reduce the metal to the state of oxide before it can act upon it. One part of the acid is consequently employed in disposing the metal for solution, and the other dissolves it in proportion as it is oxidized. This is what happens  
when



when the fulphuric acid is digested upon a metal; one portion is decomposed, and reduces the metal into an oxide, while the other dissolves it.

The manner of effecting the solution of mercury in the nitric acid, has an influence on the properties of the mercurial nitrate. Bergmann has observed that the solution which is made slowly and quietly, without disengagement of nitrous gas, affords no precipitate on the addition of water; whereas that which is made by the assistance of heat, and with loss of nitrous gas, affords a precipitate. It appears that the nitric acid, assisted by heat, is capable of becoming loaded with an excess of mercurial oxide, which it lets fall when diluted with water.

The method of performing the solution, and the process made use of to crystallize it, have an equal influence upon the form of the crystals. 1. The solution made in the cold, and left to spontaneous evaporation, affords crystals which appeared to Mr. De Lisle to be octahedral pyramids, truncated near their base, and having the four angles resulting from the junction of the bases of their pyramids likewise truncated. 2. If the same solution be evaporated, long and acute blades are obtained, lying one upon the other, and striated obliquely across. 3. The solution



of mercury effected by heat, affords flat and acute needles, striated lengthways.

The nitrate of mercury is corrosive; it detonates upon coals when it is very dry, and emits a whitish flame of considerable brilliancy.

The mercurial nitrate, heated in a crucible, is fused, and emits a considerable quantity of nitrous gas, together with its water of crystallization. The remaining oxide becomes yellow; and at length assumes a lively red colour, and forms the substance called Red Precipitate. In order to make a very fine red precipitate, the mercurial solution must be put into a retort, and distilled until no more vapours come over. An additional quantity of nitric acid must then be poured on the remainder, and likewise distilled off. After three or four repeated distillations, a very beautiful precipitate is obtained in small crystals, of a very superb red colour.

The solution of mercurial nitrate forms mercurial water. It is of use to ascertain the presence of sulphuric and muriatic salts in mineral waters.

The acids, the alkalis, the earths, and some of the metals, likewise precipitate mercury from its solution in the nitric acid. These precipitates always consist of the oxides of mercury in a greater or less degree of perfection, according to



to which circumstances their colour is subject to variation. On this head, Lemery, Baumé, &c. may be consulted.

Mr. Bayen has discovered that some of these precipitates possess the property of fulminating, when mixed with a small quantity of sublimed sulphur. This chemist has pointed out three—  
1. The precipitate of mercury from its solution in the nitric acid by the assistance of the carbonate of ammoniac. 2. The precipitate of the same fluid by lime-water. 3. The precipitate of the solution of corrosive sublimate by lime-water. Half a gros is to be triturated with six grains of sublimed sulphur. After the detonation, a violet-coloured powder remains, which affords a fine cinnabar by sublimation.

3. The muriatic acid does not sensibly act upon mercury: but if it be digested for a long time upon the metal, it oxides it, and at length dissolves the oxide, as may be concluded from the experiments of Homberg, inserted in the volume of the Academy of Sciences for the year 1700.

The muriatic acid completely dissolves the mercurial oxides. When these oxides are nearly in the metallic state, or charged with a small quantity of oxigene, the muriate of mercury is formed. When, on the contrary, the oxide  
of



of mercury is saturated with oxigene, the oxygenated muriate of mercury, or corrosive sublimate of mercury, is formed.

Corrosive sublimate may be formed according to two methods; in the dry way, or in the humid way.

To make this salt in the dry way, the operator may proceed in various manners.

1. Equal parts of dried nitrate of mercury, decrepitated muriate of soda, and sulphate of iron calcined to whiteness, are mixed together. This mixture being exposed to sublimation, the product which arises is corrosive sublimate.

2. Running mercury is used in Holland instead of the nitrate of mercury; and the same results may be obtained by using any oxide of mercury whatever.

3. Equal parts of the sulphure of mercury, and the decrepitated muriate of soda, afford the same salt by sublimation. This process of Kunckel has been revived by Boulduc.

4. Mr. Monnet assures us that he obtained corrosive sublimate by treating the dry muriate of soda, and a mercurial oxide, in the way of distillation in a retort.

If mercury be dissolved in the oxygenated muriatic acid, the solution, when concentrated, affords very fine corrosive sublimate.



It may likewise be obtained by precipitating the mercury from mercurial water by the same acid, and evaporating the solution.

I have obtained very fine sublimate by presenting a mercurial oxide, sufficiently loaded with oxigene, to the ordinary muriatic acid. One pound of muriatic acid, at the strength of twenty-five degrees, poured upon one pound of red oxide by the nitric acid, discolours it, in a short time dissolves it with a violent heat; and this solution, diluted with water, and properly evaporated, affords from twelve to fourteen ounces of crystals of corrosive sublimate.

The corrosive muriate of mercury has a styptic taste, followed by an exceedingly disagreeable metallic taste. When placed on hot coals, it is dissipated in fumes; when slowly heated in subliming vessels, it rises in prismatic crystals, so much flattened, that their faces are scarcely distinguishable. The assemblage of these has induced authors to compare them to sword blades lying across each other.

This salt is soluble in nineteen parts of water; and when the solution is concentrated, it affords crystals similar to those obtained by sublimation.

Barytes, magnesia, and lime decompose this salt. Half a gros of corrosive sublimate in powder,



der, thrown into a pint of lime-water, forms a yellow precipitate. This fluid is known by the name of Phagedenic Water.

Fixed alkali precipitates the mercury in an orange-coloured oxide; and volatile alkali in the form of a white powder, which becomes brown in a short time.

The same muriatic acid, combined with a less perfect oxide of mercury, forms the mild muriate of mercury, or *mercurius dulcis*. This combination may likewise be made by two methods; by the dry, or the humid way.

1. In the dry way, four parts of corrosive muriate of mercury are triturated in a mortar with three of running mercury. When the mercury has disappeared, the mixture is put into phials, and sublimed three successive times, in order that the combination may be more accurate. This sublimate differs from corrosive sublimate by its insolubility in water, its insipidity, and the form of its crystals, which are tetrahedral pyramids, terminated by four-sided pyramids. To obtain this regular form, it is necessary that the sublimation should be made at a moderate heat; for, if the heat be sufficient to liquefy the salt, the result is merely a crust, with no appearance of crystals. As the trituration of corrosive sublimate is dangerous, on ac-



count of the powder which rises, Mr. Baumé pours a small quantity of water upon the mixture. This liquid accelerates the trituration, and prevents the rising of the destructive powder.

Mr. Bailleau has likewise proposed the incorporating of corrosive sublimate with water, and triturating it with running mercury. The combination is completed by digesting the mixture on a sand-bath by a gentle heat. The matter becomes white, and requires only a single sublimation. Whenever it is suspected that mercurius dulcis still retains a portion of corrosive sublimate, nothing more is necessary to be done than to triturate it, and pour boiling water upon it; for by this means the whole of the soluble salt which may have remained is carried off.

Mr. Baumé has proved that there is no intermediate state between mercurius dulcis and corrosive sublimate. If less mercury be added to the sublimate, a proportional quantity of mercurius dulcis only sublimes, and the rest rises in the form of corrosive sublimate; if a greater quantity of mercury be added than is necessary to convert the whole into mercurius dulcis, the excess remains in the form of running mercury.

The same chemist has likewise proved, that a portion



portion of the mercury is always lost at each sublimation; and that a small quantity of corrosive sublimate is formed, which arises from the alteration of the mercury. Hence it follows that the mercurial panacea, which is made by subliming mercurius dulcis eight or nine times, is a more suspicious remedy than the mercurius dulcis itself.

2. Mercurius dulcis may likewise be made by decomposing mercurial water by a solution of the muriate of soda. The white precipitate which is obtained may be sublimed, and forms an excellent mercurius dulcis. I communicated this process to the Society of Sciences at Montpellier, two years before Mr. Scheele made it known.

The corrosive muriate of mercury differs therefore from the mild muriate by the state of its acid.

The mercurial oxides are equally soluble in the other acids.

3. A solution of borax, mixed with mercurial water, forms a very abundant yellow precipitate, which is nothing else but the combination of the acid of borax and mercury. A small quantity of this salt remains in solution, which may be obtained in brilliant crystals by evaporation.



4. The acetous acid likewise dissolves the oxide of mercury, and affords white foliated crystals.

Mercury precipitated from a solution of the acetate of mercury, combines with the acidulous tartrate of pot-ash, and forms the vegeto-mercurial water of Preßavin.

The acetate of mercury is the basis of Keyser's pills.

5. Mercury, artificially mixed with sulphur, forms the red or black sulphures, known, on account of their colour, by the names of Æthiops or Cinnabar.

To form the æthiops, or black oxide of mercury, three methods may be followed.

1. Four ounces of mercury may be triturated with twelve ounces of sublimed sulphur in a glass mortar. The result is a black powder, called Æthiops Mineral.

2. Four ounces of sulphur may be fused in a crucible, and one ounce of mercury extinguished in it. The mixture readily takes fire, but the inflammation is to be prevented; and the blackish residue, being pounded, affords a greenish powder, which is a true æthiops.

3. The æthiops may be made by pouring the sulphure of pot-ash upon mercurial water.

These æthiops afford by sublimation cinnabar,



bar, or the red sulphurated oxide. But in order to make it with a greater degree of accuracy, four ounces of sublimed sulphur are fused in an unglazed earthen pot, and one pound of mercury mixed with it by stirring or agitation. When these substances have combined to a certain degree, the mixture spontaneously takes fire, and is suffered to burn about a minute. The flame is then smothered, and the residue pulverized, which forms a violet powder, usually weighing about seventeen ounces five gros. This powder, being sublimed, affords a sublimate of a livid red colour; which, when pounded, exhibits a fine red colour, known by the name of Vermilion.

Three parts of cinnabar, mixed with two ounces of iron filings, afford very pure mercury by distillation, which is called mercury revived from cinnabar. Lime, the alkalis, and most of the metals, may be substituted instead of the iron.

Mercury amalgamates with most other metals. On this property is founded the art of water-gilding, or gilding upon metals, the tinning of glasses, the working of gold and silver mines, &c.

Mercury is likewise used in the construction of meteorological instruments, in which it possesses the advantage over other fluids—1. That



it does not easily freeze. 2. It is more easily and gradually dilatable, according to the fine experiments of Messrs. Bouquet and Lavoisier. 3. It is very nearly of the same quality in different specimens.

Mercury may be used in substance as a remedy against the *volvulus*, and it has never been observed to produce bad effects. It is mixed with fat, to form unguents very much used in venereal cases. These are prepared with one-third or half their weight of mercury, according to the exigence of the case.

The mercurial water is used as an *escharotic*.

The red oxides answer the same purpose.

The mild mercurial muriate is used as a purgative. It enters into the composition of pills which are used in venereal cases, with the intention of carrying off the morbid matter by the skin.

The corrosive muriate of mercury is of very extensive use, more especially against venereal disorders. This remedy requires skill and prudence; but I have received it as the common opinion of all physicians of reputation, that it is the most powerful and certain remedy possessed by the art of medicine. In a large dose it irritates the system, affects the stomach, occasions



occasions, spasms in the lower belly, and leaves impressions which are difficult to be eradicated.

Cinnabar is used in fumigations, to destroy certain insects which attach themselves to the skin. It is likewise used as a pigment.

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### C H A P. XIII.

#### *Concerning Silver.*

**S**ILVER is a metal of a white colour, possessing neither smell nor taste, nearly unalterable by fire, very ductile and tenacious. A cubic foot of this metal cast weighs seven hundred and twelve pounds; the specific gravity of cast silver is 10,1752. See Briffon.—It is found in the earth in five different states, which we shall proceed to consider.

1. Virgin or native silver.—Native silver is found in various forms. 1. In ramifications composed of octahedrons inserted one in the other. This variety is known by most mineralogists under the name of Virgin Silver in Vegetation. Four processes, indicated by Mr. Sage,



Sage, are known for the crystallization of silver : amalgamation, reduction by phosphorus, reduction by copper, and fusion.

A detail of these four processes may be seen in his *Analyse Chimique*, book iii. p. 238 et seq.

Native silver is likewise found in small capillary, flexible, and intertwined threads. The decomposition of the red or vitreous silver gives rise to this species ; it may even be produced by a slow calcination of one of these ores.

Silver is likewise found in irregular forms ; either in small plates dispersed in the gangues, or in masses. Albinus reports, in the *Chronicle of the Mines of Misnia*, that in the year 1478 a lump of native silver was found at Schnee-burg, weighing four hundred quintals. Duke Albert of Saxony descended into the mine to see this surprising mass of silver, and had dinner served up upon it.

2. The vitreous silver ore, or silver mineralized by sulphur.—This ore is of a grey colour, and may be cut like lead. It crystallizes in octahedrons, or in truncated cubes, and is most frequently found of an indeterminate figure. The sulphur may be extracted by heat. It affords about sixteen pounds in the quintal.

When the sulphur is contained in a greater



proportion in this ore, it becomes black, porous, and friable.

3. Red silver ore: silver mineralized by sulphur and arsenic.—This species crystallizes in hexahedral pyramids, terminating in an obtuse trihedral pyramid, with rhombic faces. It is frequently found in irregular masses of no determinate figure. It possesses the colour and transparency of the ruby.

Mr. Sage has obtained from this ore, by distillation, water, carbonic acid, and the sulphurated yellow and red oxides of arsenic. If this ore be calcined in a test, and the mineralizer be suffered to exhale, the residue is found to be in the metallic state, exhibiting contorted threads of silver at its surface. Part of the silver passes to the state of grey oxide in this operation.

4. White antimonial silver ore: silver and antimony mineralized by sulphur.—This ore is as white as silver; it is brittle, and of a granulated fracture. Sometimes it is found in hexahedral prisms, truncated, and flat at each end: this kind is found in the principality of Furstenburg. When exposed to heat, it becomes as fluid as water, emits antimony and sulphur, and leaves the silver behind, together with an oxide of antimony. This semi-metal is cleared  
off



off by fusion, assisted by proper fluxes, and cupellation.

5. The corneous ore of silver, or muriate of silver.—This species is of a dirty yellow grey: it is soft, and may be easily broken or cut. A gentle heat causes it to flow; it sublimes without decomposition, is most frequently found of no regular form, but sometimes crystallized in cubes. The muriatic acid is its mineralizer. Mr. Woulfe has shewn that it likewise contains a small quantity of sulphuric acid.

6. Silver is also very frequently alloyed with various metals, such as lead, copper, bismuth, cobalt; and these ores are sometimes wrought on account of the quantity of silver they contain.

The manner of working a silver ore varies according to its nature; but all the processes used in various countries may be reduced to the following:

1. In Peru and Mexico the mineral is pounded, roasted, washed, and afterwards triturated with mercury in copper boilers filled with water kept at the boiling heat. The whole is agitated by means of a kind of mill. The amalgam is afterwards expressed in a skin; then heated, to drive off the remaining mercury; after which process the silver remains alone.

This



This method is defective—1. Because the fire volatilizes a portion of the muriate of silver which abounds in these ores. 2. The washings carry with them a portion of the oxide of silver. 3. The mercury does not amalgamate either with the muriates of silver, or the sulphates of that metal.

2. When silver ores, mineralized by sulphur or arsenic, are to be wrought, they are roasted, pounded, washed, and fused with lead. This metal seizes all the silver, from which it is again separated by cupellation.

3. When the silver ore is poor, it is fused with cupreous pyrites, and the mixture treated in the way of liquation.—See the article Lead.

To determine the degree of purity of the silver, a given weight of silver is supposed to be composed of twelve parts, called pennyweights; each pennyweight is divided into twenty-four grains. Silver, clear of all mixture, is said to be twelve pennyweights fine.

In order to assay silver, and to ascertain its degree of fineness, the regulation of the Court of Monies of France prescribes, that thirty-six grains of silver be taken, and wrapped in a plate of lead containing no fine metal, and then exposed to cupellation. From the loss which the button of silver that remains on the cupel has suffered,



suffered, a judgment is made of the quantity of alloy. If the loss be one twelfth of the whole, the silver is said to be eleven pennyweights fine. The details relating to this operation may be seen in *L'Art d'essayer l'Or et l'Argent, par M. Sage.*

Silver may be rendered hard by mixing it with copper; and for this reason it is alloyed with that metal for silversmiths' work, as well as for the coinage. The law permits one-twelfth of alloy in silver money\*; and it is this portion of copper which renders the solution of silver coin in the nitric acid blue.

Silver is not changed by the contact of air. A considerable heat is required to fuse it; but it may be volatilized by a strong fire without alteration, as is proved by the capital experiments of the Academicians of Paris, made in the focus of the lens of Mr. Trudaine. This metal emits a thick fume, which whitens plates of gold exposed immediately over it.

Junker converted silver into glass, by treating it in a way of reverberation, after the manner of Isaacus Hollandus, in a very strong fire.

Macquer, by exposing silver twenty times successively to the porcelain furnace of Seves, obtained glass of an olive green colour. It was likewise observed that this metal, when exposed

\* The British coinage is 11 ounces 2 pennyweights fine. T.



to the focus of a burning mirror, presented a white pulverulent matter on its surface, and a greenish vitreous covering on the support upon which it was placed.

Though these experiments clearly prove that silver is capable of combining with oxigene, the difficulty which is found in effecting this combination, and the facility with which this air is disengaged from the oxides of silver, prove that there is but little affinity between these two substances.

If silver in a state of extreme division be presented to the concentrated and boiling sulphuric acid, sulphureous gas is disengaged: the silver is reduced into a white matter, which is a true oxide of silver; and contains a small quantity of sulphate, which may be obtained in small needles, or in plates formed by the union of these needles lengthways, as Mr. De Fourcroy has observed. This salt flows by heat, and is very fixed. If silver be precipitated by metals or alkalis, these precipitates are reducible without addition.

The nitric acid dissolves silver with rapidity: much nitrous gas is disengaged. The solution is at first blue: but this colour disappears when the silver is pure; and degenerates into a green colour, if it be alloyed with copper. The nitric  
acid



acid is capable of dissolving more than half its weight of silver. The solution then lets fall crystals in hexagonal, triangular, or square plates, which are called Nitrate of Silver, Lunar Crystals, Lunar Nitre, &c.

The solution of these crystals, generally known by the name of Solution of Silver, is very caustic. It colours the skin black, burns the epidermis, and so completely destroys its organization, that the spot disappears only by the renewing of the skin.

The nitrate of silver melts on burning coals; but if it be exposed to a gentle heat, in earthen or metallic vessels, it liquefies, and may then be cast in moulds. This fused nitrate of silver forms the lapis infernalis. Care must be taken to pour it out as soon as it is fused; because otherwise the acid would be disengaged, the silver would be revived, and the lapis infernalis, or lunar caustic, would lose its virtue.

Lapis infernalis, made with pure silver, and prepared as above described, is whitish; whereas it is blackish when suffered to remain in fusion for any time.

Lapis infernalis is very frequently mixed with nitrate of copper. This fraud is reprehensible, because it is an alloy which renders wounds of a bad character.



The lapis infernalis is used as an escharotic, and to corrode fungous excrescences.

Silver may be precipitated from its solution by lime-water, alkalis, and several metals. These last exhibit very important phenomena.

1. A plate of copper, immersed in a solution of silver diluted in water, precipitates the metal. It adheres at the moment of precipitation to the surface of the copper, where it forms a kind of moss. In proportion as the silver is precipitated the water assumes a blue tinge; which proves that the copper is dissolved in the nitric acid, in the room of the silver. When the whole of the silver is disengaged, the water is to be decanted, the silver dried, and fused in crucibles, to be cast into ingots. This silver almost always retains a small quantity of copper; of which it may be deprived by cupellation with lead, which renders the silver pure: this process is used in the mints, where the parting operation of gold from silver is performed. The first step consists in separating the silver by means of nitric acid; and this is afterwards precipitated by the addition of copper.

2. The silver is likewise precipitated by mercury. In this operation it amalgamates with a small quantity of the mercury, and forms tetrahedral crystals terminated by a tetrahedral py-



ramid, which crystals are articulated into each other. This arrangement gives them the form of a vegetation; and has caused the precipitate to be known by the name of the Tree of Diana, *Arbor Dianæ*. Lemery, Homberg, and other chemists, have successively published processes to produce this phenomenon; but that which has succeeded best in my hands, is described by Mr. Baumé. Six gros of the solution of silver, and four of that of mercury, both well saturated, are taken, and diluted with five ounces of distilled water. These are to be put into a conical vessel; and an amalgam of seven parts of mercury, and one of silver, is to be poured in. A multitude of small crystals instantly appear to disengage themselves from the surface of the amalgam, upon which new ones articulate themselves; and a vegetation is produced, which perceptibly rises under the eye of the spectator. To render this phenomenon more striking, I decant the exhausted water, and substitute fresh; by this means I can fill any vessel whatever with these vegetations. The mercury amalgamated with the silver, in this operation, may be separated by means of fire.

The muriatic acid does not dissolve silver, but it speedily dissolves its oxides. The oxygenated muriatic acid dissolves silver.



To produce a certain and speedy combination of the muriatic acid with silver, this acid is to be poured into a solution of the nitrate of silver. A precipitate immediately falls down, which is known by the name of Luna Cornea. This muriate of silver is very fusible; and runs into a grey and transparent substance, considerably resembling horn. If a stronger degree of heat be applied, it is decomposed, part is volatilized, and the other part reduced into silver.

The muriate of silver, exposed to the light of the sun, becomes brown in a short time. Oxygenous gas is disengaged; which may be collected by placing it under water, according to the process of Mr. Berthollet. Most of the solutions of the metals have the same property. Lunar nitre likewise becomes coloured, and emits its oxigene and nitrous gas.

One pound of boiling water does not dissolve more than three or four grains of muriate of silver, according to the observation of Mr. Monet. The alkalis are capable of decomposing the muriate of silver, and separating the metal. The silver may be disengaged from its muriate by fusion with three parts of black flux.

Mr. Berthollet has taught us the following



process, to form the most dreadful and the most astonishing fulminating powder we have yet been acquainted with. Take fine silver of cupellation; dissolve it in the nitric acid; precipitate this solution by lime-water; decant the water, and expose the oxide for three days to the air. Mr. Berthollet is of opinion that the presence of light has some influence in the success of this experiment.

Mix this dried oxide in ammoniac, or volatile alkali, and it will assume the form of a black powder: decant the fluid, and leave the powder to dry in the open air. This is the fulminating silver.

Gunpowder, and even fulminating gold itself, cannot be compared with this new product. The contact of fire is necessary to cause gunpowder to detonate; and a determinate degree of heat is required to cause fulminating gold to fulminate: but the contact of a cold body is sufficient to produce the detonation of fulminating silver. In a word, this product, once obtained, can no longer be touched: no attempts must be made to inclose it in a bottle, but it must be left in the capsule wherein the evaporation was performed.

It is useless to observe, that the fulmination ought not to be attempted but with small quantities;



tities; the weight of a grain, for example: for a larger mass would give rise to a dangerous detonation. The necessity of making this preparation with the face covered with a mask with glass eyes, may be easily conceived. It is prudent to dry the fulminating silver in small metallic capsules.

The following experiment will complete the notion which ought to be formed of the fulminating property of this preparation.

Take the ammoniac which was used in the conversion of the oxide of silver into the black precipitate which forms fulminating silver; put this ammoniac into a small matrafs of thin glass, and let it be subjected to the degree of ebullition necessary to complete the combination. Take the matrafs from the fire; and a rough covering of crystals will be formed on its internal surface which is beneath the fluid. If one of these crystals beneath the cold fluid be touched, an explosion takes place which breaks the matrafs.

The process for obtaining fulminating silver being described, its effects known, and the cautions necessary for repeating the experiment being well ascertained, we shall speak a word concerning the theory of the phenomenon: it is



the same as that of fulminating gold, laid down by Berthollet.—See the Memoirs of the Royal Academy of Sciences for the year 1785.

In this operation, the oxigene, which adheres very slightly to the silver, combines with the hydrogen of the ammoniac. From the combination of the oxigene and the hydrogen, water in the state of vapour is produced. This water, instantly vaporized, and possessing all the elasticity and expansive force of that state, is the principal cause of the phenomenon; in which the nitrogene, which is disengaged from the ammoniac, with its whole expansibility, likewise bears a principal part.

After the fulmination, the silver is found reduced or revived; that is to say, it has resumed its metallic state. It again becomes the same white, brilliant, and pure metal which it was when taken out of the cupel.

The principal use of silver is in coinage, as the representative sign of the value of other commodities.

Its metallic brilliancy has caused it to be adopted as an ornament; its hardness, and unchangeableness in the air, render it very valuable.

It is alloyed with copper, to form solder;  
whence



whence it happens that silver utensils are subject to rust and verdigris, at the places where they are foldered.

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## C H A P. XIV.

*Concerning Gold.*

**G**OLD is the most perfect, the most ductile, the most tenacious, and the most unchangeable, of all the known metals. A cubic foot of pure gold, cast and not hammered, weighs 1348 pounds; and its specific gravity is 19,2581.—See Briffon.

Gold has neither smell nor taste; its colour is yellow, and this varies according to the purity of the metal.

1. As gold is subject to very little alteration, it is almost always found in the native state; and under this form it exhibits the following varieties:—1. It is found in octahedrons in the gold mines of Boitza in Transylvania. These octahedrons are sometimes truncated in such a



manner as to have the appearance of hexagonal plates. This native gold is alloyed with a small quantity of silver; which, according to Mr. Sage, gives it a pale yellow colour. It has likewise been found crystallized in tetrahedral prisms, terminated by four-sided pyramids. The amalgam made with certain precautions is likewise capable of causing gold to assume a form nearly similar, according to Mr. Sage; and gold reduced by phosphorus sometimes exhibits octahedral crystals.

Gold likewise crystallizes by fusion. Messrs. Tillet and Mongez obtained it in short quadrangular pyramids.

2. Native gold sometimes exhibits fibres or filaments of various lengths; it is likewise found in plates disseminated on a gangue. The gold ore of Lagardet, a few leagues distant from Allemont in Dauphiny, is of this kind. 3. Gold is likewise found sometimes in small plates or spangles, dispersed in sand or earths: under this form it is found in the auriferous rivers, such as the Ariege, the Ceze, the Gardon, the Rhone. These small plates are sometimes one line in diameter, but most commonly too small to be seen by the naked eye. 4. Gold is sometimes found in irregular masses; in which instance it is known by the name of Gold Dust. Very large



large pieces of this kind are found in Mexico and Peru.

2. Gold is sometimes mineralized by sulphur, by the means of fire. The auriferous pyrites are frequently found in Peru, Siberia, Sweden, Hungary, &c. To ascertain whether a pyrites contains gold or not, it must be pounded, and nitric acid poured upon it until it takes nothing more up. This solution must then be diluted with much water. The lightest insoluble parts may be carried off by washings; and the residue, upon examination, will shew whether it contains gold or not.

When the martial pyrites is decomposed, the gold is always disengaged; and it is probable that the small plates of gold in the auriferous rivers are afforded by a decomposition of this kind.

Gold is sometimes mineralized by sulphur, with the assistance of zinc, as in the gold mine of Nagyag. This ore likewise contains lead, antimony, copper, silver, and gold.

3. Mr. Sage has given a description and analysis of an arsenical ore of gold.

4. Gold likewise exists naturally in vegetables. Becher obtained it. Henckel affirmed that they contain it; and Mr. Sage has resumed this enquiry, and found it according to  
the



the following table, which expresses the quantities of gold obtained from the quintal of the several earths.

	Ounce.	Gros.	Grains.
Rotted manure (terreau)	0	1	56
Earth of uncultivated ground (terre de Bruyere)	0	2	36
Garden mould	0	5	0
Mould of a kitchen garden manured with dung yearly for sixty years	2	3	40

These results were at first contested; but at present it appears to be generally agreed that gold is obtained, but in a less quantity. Mr. Berthollet obtained forty grains and eight twenty-fifths of gold in the quintal of ashes. Messieurs Rouelle, Darcet, and Deyeux likewise obtained it.

It is therefore a physical fact, that gold exists in vegetables.

The method of working the ores of gold is nearly the same as that used with silver ores. When the gold is in a native state, nothing more is required than to divide the ore by the pounding mill, and afterwards to wash and amalgamate it. If the ore be mineralized, it is torrefied, pounded, washed, fused with lead, and afterwards cupelled. Eliquation is likewise used for poor ores.

Those



Those persons who explore the gold in small plates disseminated in the sand of certain rivers, are known in France by the name of Orpailleurs, or Pailloteurs. The pailloteurs of the river Uze, after having ascertained that the earth is sufficiently rich to be wrought, place a table of several feet in length, and about a foot and a half in width, on the banks of the river, with ledges round three of its sides. Pieces of stuff with a long nap are nailed on to this board; and the sand is thrown upon it, and washed, to carry away the lighter particles. When the stuff is sufficiently charged with the small particles of gold, it is shaken into a vessel, agitated with water, to carry off the lightest sand, and afterwards amalgamated with mercury\*. Mr. Ell has given us an ample account of the process used in working the gold ores in Spanish South America. A sufficient quantity of water

\* For a very full account of the treatment of auriferous sands, the following works may be consulted:—1. The Memoir of Mr. Reaumur on the Auriferous Sands of France, printed among those of the Academy for the year 1718. The Memoir of Mr. Guetard on the Ariege, inserted in the volume for 1761. 3. The Memoir upon the Gold which is obtained from the Ariege in the county of Foix, by the Baron de Dietrich. In this last work, the various processes are discussed; and this celebrated mineralogist proposes others more economical and advantageous.



is procured to wash them. A stream is made to carry off the earth, and every lighter substance. Negro slaves, dispersed on the banks, throw in fresh earth; while others, standing in the brook, work it about with their feet and hands. Care is taken to lay pieces of wood across the current of the water, to retain the lighter particles of the metal. This work is continued for a month, and even for years together. When it is proposed to terminate it, the water is turned off; and then, in presence of the master, the workmen take up the sand with wooden vessels, in the form of shallow funnels, of one foot in diameter, at the bottom of which is an aperture of one inch in width. This dish is filled with sand; and by a circular motion the lighter substances are caused to flow off, while the heavier settle to the bottom. The platina is afterwards separated grain by grain, with the blade of a knife, upon a smooth board. The rest is amalgamated, first by working with the hands, and afterwards with a wooden pestle in mortars of guaiacum wood; after which the mercury is separated from the gold by fire.

The Baron de Born has reduced the method of working all the ores of silver and gold to one single process. The account which he has given



of this process in his work, may be reduced to the following operations :

1. The mineral is pounded, divided, and sifted.
2. It is properly roasted.
3. It is mixed with muriate of soda, water, and mercury ; and agitation is used to facilitate the amalgamation.
4. The mercury is expressed from the amalgam.
5. The expressed mercury is exposed to distillation.
6. The silver is refined by the cupel.

These operations were first executed at Schemnitz in Hungary, and afterwards at Joachimstal in Bohemia, in the presence of the greatest mineralogists in Europe, sent thither by the various sovereigns of Europe.

The muriate of soda is used to decompose the sulphates produced by the calcinations.

To determine the fineness of gold with accuracy, the purest is supposed to be twenty-four carats, and these carats are divided into thirty-second parts ; the carat is always represented by a grain poids de marc.

The law directs the operations to be performed upon twenty-four grains of gold, tolerates twelve, and prohibits six, on account  
of



of the difficulty of appreciating the divisions which result from these small quantities.

In the parting assay, very pure silver must be made use of. This is mixed with the gold in the proportion of four to one, which has occasioned the name of Quartation to be given to the process. Mr. Sage has found that two parts and a half of silver to one of gold form the mixture most proper for making the cornet of assay. The two metals are wrapped up in a thin piece of lead four times the weight of the gold, and this mixture is put into the cupel when it is very hot. The result of the cupellation is a button containing fine gold and fine silver. This is flattened, lamellated, and rolled up into a spiral; put into a small matrafs, and six gros or drams of pure nitric acid, at thirty-two degrees of concentration, are poured on it. As soon as the matrafs is heated, the metal becomes brown, the silver is dissolved, and much red vapours are disengaged. At the end of fifteen minutes the solution is decanted; and an ounce of very pure acid, rather more concentrated, is poured on, to carry away the last portions of silver. This solution is decanted, after a digestion of fifteen or twenty minutes; at which period warm water is added, and the cornet is washed until the water comes off tasteless. It is



then dried in a crucible, weighed, and the fineness judged by the diminution of its weight.

Schindlers and Schutler have maintained that gold always retains a small quantity of silver, which they have called the *Interhalt*, or *Surplus*. Mr. Sage found a sixty-fourth part of a grain in the best conducted assay.

In order to separate the silver which is dissolved in the nitric acid, this solution is diluted with a considerable quantity of water, and flat pieces of copper are plunged in it; which precipitate the silver, as we have observed in treating of the solution of silver.

Gold, exposed to fire, becomes red-hot before it melts. When melted it suffers no alteration\*. Kunckel and Boyle kept it in a glass-house furnace for several months without change.

Homborg has nevertheless observed that this metal, exposed to the focus of the lens of Tschirnaus, smoked, was volatilized, and even vitrified in part. Mr. Macquer has verified this observation by the mirror of Mr. De Trudaine; he observed the gold fume, become volatilized, and covered with a dull pellicle, which

\* Gold, when fused by a strong heat, is of a beautiful green colour during the fusion. T.



constituted a violet-coloured oxide towards the middle.

Gold is not attacked by the sulphuric acid.

The nitric acid appears to have a real action upon it. Brandt is the first who announced the solution of gold by this acid. The experiments were made in the presence of the King of Sweden, and verified by his Academy. Messrs. Scheffer and Bergmann have confirmed the assertion of Brandt; and Mr. Sage afterwards published a series of experiments on this subject. I am convinced, from my own experiments, several times repeated, that the purest nitric acid attacked gold in the cold, and dissolved a sixty-fourth part of a grain. When very pure nitric acid is boiled upon gold equally pure, the solution may be ascertained in three ways—1. By the diminution of the weight of the metal. 2. By evaporation of the acid; in which case a purple spot remains at the bottom of the evaporatory vessel. 3. By the parting operation, by means of a plate of silver put into the liquor. In this case black flocks are in a short time disengaged, which consist of the gold itself. These phenomena appear to announce a true solution; and not a simple division or suspension, as was supposed.

The quantity of gold dissolved appeared to  
me



me to vary according to the strength of the acid, the time of the ebullition, and the thickness of the metallic body.

The nitro-muriatic acid, and the oxygenated muriatic acid, are the true solvents of gold. These acids attack it with greater energy in proportion as they are more concentrated, and as the surface of the gold is larger. The solution may likewise be accelerated by heat.

This solution has a yellow colour, is caustic, and tinges the skin of a purple colour. If it be properly concentrated, it affords yellow crystals, resembling topazes, which affect the form of truncated octahedrons. These crystals are a true muriate of gold, according to Messrs. Bergmann, Sage, &c. If the solution of gold be distilled, a red liquor is obtained, which consists of the muriatic acid, coloured by a small quantity of gold which it has carried over. This fluid was distinguished by the adepts under the name of Red Lion.

Gold may be precipitated from its solution of several colours, according to the nature of the substances employed to make the precipitation. Gold is precipitated by lime and magnesia in a yellow powder, in which the gold exists nearly in the metallic state; a slight de-



gree of heat only being necessary to convert it to that state.

The alkalis likewise precipitate gold in the form of a yellowish powder; and the precipitate is soluble in the sulphuric, nitric, and muriatic acids. These concentrated solutions suffer the gold to precipitate; crystals have not been obtained from them.

If ammoniac be poured on a yellowish solution of gold, the colour disappears; but, at the end of a certain time, small flocks are disengaged, which become more and more yellow, and gradually subside to the bottom of the vessel. This precipitate, being dried in the shade, is known by the name of Fulminating Gold; a denomination which it has obtained on account of its property of detonating, when gently heated.

Ammoniac is absolutely necessary to produce this effect.

The experiments of several chemists have taught us—1. That, by gently heating fulminating gold in copper tubes, one extremity of which was plunged in the pneumato-chemical apparatus by the assistance of a syphon, alkaline gas is obtained, and the precipitate is deprived of its fulminating property: this fine experiment



ment was made by Mr. Berthollet. 2. Bergmann has observed that, by exposing fulminating gold to a gentle heat, incapable of causing it to fulminate, it becomes deprived of that property. 3. When the gold is made to fulminate in tubes whose extremities are inserted under a vessel filled with mercury, the product is nitrogene gas, and some drops of water. 4. By triturating fulminating gold with oily substances, it is deprived of its property of fulminating.

From these established facts, it is evident that fulminating gold is a mixture of ammoniac and oxide of gold. When this mixture is heated, the oxigene is disengaged at the same time with the hydrogene of the alkali. These two gases take fire by simple heat, detonate, and produce water; the nitrogene gas then remaining alone. From these principles it ought to follow, that oily substances which combine with the oxigene, acids which seize the alkali, or a gentle and long-continued heat, which volatilizes the two principles without inflaming them, ought to deprive this preparation of its property of fulminating.

The nitrous sulphur which Mr. Baumé supposed to be formed, in his explanation of this phenomenon, does not exist; for the solution of the oxide of gold by the sulphuric acid, when



precipitated by ammoniac, affords a fulminating precipitate.

Gold is precipitated from its solution by several metals, such as lead, iron, silver, copper, bismuth, mercury, zinc, and tin. This last precipitates it instantly in the form of a powder, distinguished by the name of the Purple Powder of Cassius. This precipitate is much used in porcelain manufactories. Some very good observations on this preparation may be seen in the Dictionary of Macquer.

Gold may likewise be precipitated from its solution by ether: this liquor seizes the gold in a moment, and sometimes instantly revivifies it. I have seen the gold form a stratum at the surface of the liquor, and the two fluids no longer contained a particle.

The sulphures of alkali dissolve gold completely. Nothing more is necessary for this purpose, than quickly to fuse a mixture of equal parts of sulphur and pot-ash with one-eighth of the total weight of the gold in leaves. This substance may then be poured out, pulverized, and dissolved in hot water. The solution has a yellowish green colour. Stahl affirms that Moses dissolved the golden calf by a similar process; and that, though the beverage must have been  
of



of a disagreeable taste, this circumstance was an additional reason for preferring the method, in order that the Israelites might longer retain their disgust for idolatry.

Gold unites with most of the metals.

Arsenic renders it brittle, as well as bismuth, nickel, and antimony. All these semi-metals render it white and eager.

Gold unites very well with tin and lead. These two metals deprive it of all its ductility.

Iron forms a very hard alloy with gold, which may be employed to much greater advantage than pure gold.

Copper renders it more fusible, and communicates a reddish colour to it. This alloy forms money, gold plate, and toys.

Silver renders it very pale. This alloy forms the green gold of goldsmiths.

Gold is employed in a variety of purposes. It is entitled, by the first rank which it holds among metals, to the most noble uses.

As its colour is agreeable to the eye, and is not subject to tarnish, it is used in ornaments, or as toys; for which purpose it is wrought into a thousand forms.

For some purposes it is drawn into very fine wire, and used in embroidery. For other purposes it is extended into leaves so extremely



thin, that the slightest breath of wind carries them away : in this form it is applied upon wooden articles by means of size.

For other purposes it is reduced into a very fine powder ; in which case it is called Ground Gold, Shell Gold, Gold in Rags, &c.

The ground gold is prepared by levigating the clippings of gold leaf with honey, washing them with water, and drying the particles which subside.

Shell gold consists of ground gold mixed with a mucilaginous water.

In order to make the gold in rags, pieces of linen are steeped in a solution of gold, afterwards dried, and then burned. When it is required to use them, a wet cork is dipped in wood ashes, and rubbed upon such articles of silver as are intended to be gilded.

For some purposes it is amalgamated with mercury. This amalgam is applied upon copper, the surface being previously well cleared. It must be spread very even, and the mercury driven off by heat. This forms the *or moulu*.

A coating of gilders wax is laid over the gold thus applied. This is made with red bole, verdigris, alum, and sulphate of iron, incorporated and fused with yellow wax. The piece is heated a second time, to burn off the wax.



Gold was formerly used in medicine. This remedy was much in fashion in the fifteenth century. Its goodness has at all times been proportioned to the dearness of the drug. Bernard de Palissy exclaimed strongly against the apothecaries of his time, who demanded ducat gold from the sick to put into their medicines, under the pretence that the purer the gold the more speedy would be the restoration of the health of the patient.

As this metal is highly valued, the rage of forming it constituted a known sect, under the name of Alchemists, which may be divided into two classes. The one, very ignorant, frequently unprincipled, and most commonly uniting both qualities, suffered themselves to be imposed on by certain phenomena, such as the increase of weight of metals by calcination, the precipitation of one metal by another, and the yellow colour which some bodies, and certain preparations, affect. They grounded their notions on certain vague principles concerning the formation of bodies, their common origin, their feeds, &c.

It is this sect which has caused alchemy to be defined, *ars sine arte, cujus principium est mentiri, medium laborare, tertium mendicare*. These alchemists, after having been themselves the dupes



for a considerable time, always endeavoured to impose on others; and there are a thousand tricks and impositions related of this class of men, which deserves only to be despised and pitied.

There is another class of alchemists which does not deserve to be made the object of public derision and contempt. This is formed of celebrated men, who, grounding their ideas on the received principles, have directed their researches towards this object. This class of men is valuable on account of their genius, probity, and conduct. They have formed a language, held scarcely any communication but with each other, and have at all times distinguished themselves by their austere manners, and their submission to Providence. The celebrated Becher is a name which alone suffices to render this sect respectable. The following passage, extracted from Becher, exhibits an idea of their language, and manner of proceeding in this study.

“ Fac ergo ex lunâ et sole mercurios, quos cum primo ente sulphuris præcipita, præcipitatum philosophorum igne attenua, exalta, et cum sale boracis philosophorum liquefac et fige donec sine fumo fluat. Quæ, licet breviter dicta sint, longo tamen labore acquiruntur et itinere, ex arenoso namque terrestri Arabico mari,



in mare rubrum aqueum, et ex hoc in bituminosum ardens mare mortuum itinerandum est, non sine scopulorum et voraginum periculo, nos, Deo sint laudes, jam appulimus ad portum." Becher, *Phyf. Sub. i. f. v. cap. iii.* page 461. in 8vo. *And elsewhere*, "Concludo enim, pro thefi firmissima, asinus est qui contra alchymiam loquitur, sed stultus et nebulo qui illam practice venalem exponit."

The enlightened alchemists have enriched chemistry with most of the products which were known before the late revolution. Their knowledge and their indefatigable ardour put them in the situation of profiting by all the interesting facts which offered themselves.

God forbid that I should induce any person to enter into this path. I would use every effort to prevent any one from engaging in this research, so full of disappointment, and so dangerous to attach the mind to it. But I am of opinion that the alchemists have been too lightly treated; and that this sect, which on many accounts is worthy of commendation, has not received the esteem and gratitude it is entitled to.

In addition to these reasons, I must observe that chemical phenomena become so wonderful; the torch of analysis has enlightened us to such an extent; we now decompose and reproduce  
so



so many substances, which ten years ago were considered with equal probability as indecomposable as gold is now thought to be; that no chemist can take upon him to affirm that we may not arrive at the art of imitating nature in the formation of metals.

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C H A P. XV.

*Concerning Platina.*

**W**E were unacquainted with platina until the year 1748. It is to Don Antonio Ulloa, who accompanied the French Academicians in their famous voyage to Peru, to determine the figure of the earth, that we are indebted for our first notions of this metal.

Charles Wood, who had himself brought this metal from Jamaica, made experiments upon it, which are related in the Philosophical Transactions for the year 1749 and 1750.

Since that time, all the chemists in Europe procured this metal. Messrs. Scheffer in Sweden, Lewis in England, Margraaff in Prussia, Mac-



quer, Baumé, De Buffon, De Milly, De Lisle, De Morveau, have successively made researches on this substance: and we are indebted for great part of our present knowledge of this metal to the Baron de Sickengen.

Platina has hitherto been found only in the metallic state. Its form is that of small grains, or flattened plates, of a livid white colour, intermediate between that of silver and iron: it is from this colour that it derived its name of Platina, or Little Silver. If the grains of platina be carefully examined, it is found that some of them are rounded, and others angular.

It has been found among the auriferous sands of South America, near the mountains of the districts of Novita and Cytara. These two metals are almost constantly accompanied by a ferruginous sand obedient to the magnet. The platina of commerce usually contains a small quantity of mercury, arising from the amalgamation which the ore has undergone in extracting the gold. When it is required to have platina in a very pure state, it must be exposed to heat, to drive off the mercury; and the magnetical parts, and the iron, must be sorted out with the magnet. Platina itself is slightly attracted by the magnet. M. L. affirms, in a Memoir read to the Academy of Sciences at Paris in the year 1785, that



that the lighter pieces of platina only are attracted by the magnet, and that they cease to be acted on when they exceed a certain size. The largest piece of platina which has been seen, is of the size of a pigeon's egg. It must be in the possession of the Royal Society at Biscia.

M. L. affirms that platina is malleable in its natural state; and he passed it through the flattening mill in the presence of Messrs. Tillet and Darcet.

Platina undergoes no alteration by exposure to the air; and fire alone does not even appear to possess the power of changing it. Messrs. Macquer and Baumé kept it several days in a glass-house furnace, without its grains having suffered any other change than that they were slightly agglutinated. It has nevertheless been ascertained that heat, kept up for a long time, tarnishes its surface, and increases its weight, Margraaff formerly made this observation.

Platina, exposed to the focus of the burning mirror of Mr. De Trudaine, fumes and melts. This metal may be hammered like gold and silver. It may likewise be fused upon charcoal, by the assistance of oxygenous gas. This substance resists the action of the acids, such as the sulphuric, the nitric, and the muriatic acids; it is soluble only in the oxygenated muriatic and  
the



the nitro-muriatic acids. One pound of the latter, digested on an ounce of platina, first assumes a yellow colour, then an orange colour, and lastly a very obscure brown. This solution tinges animal substances brown; it spontaneously deposits small irregular fawn-coloured crystals; but, if it be concentrated, larger crystals are obtained, sometimes of an octahedral form, as Bergmann has observed. The muriate of platina is scarcely caustic, though sharp; it fuses in the fire, gives out its acid, and leaves an obscure grey oxide.

The sulphuric acid, poured on this solution, forms a precipitate of a dark colour; the precipitate occasioned by the muriatic acid, is yellowish.

The alkalis precipitate platina from its solution; but, if it be gradually precipitated by potash, the precipitate is dissolved by the alkali in proportion as it is formed.

A solution of the muriate of ammoniac, poured into a solution of platina, forms an orange-coloured precipitate, which is a true saline substance, totally soluble in water. This precipitate has been fused by Mr. De Lisle in a common fire (of a furnace). The result of the fusion is platina, still altered by some portion of saline



saline matter; for it does not acquire ductility but by exposure to a much stronger heat.

The property which the muriate of ammoniac possesses, of precipitating platina, affords a very simple method of ascertaining the mixture of this metal with gold: so that the fear of this alloy, which had alarmed the Spanish ministry so much as to occasion them to forbid its being wrought, does not at present exist, as we possess a simple method of ascertaining the fraud: and it is much to be wished that this very precious metal should be restored to the arts, to which it cannot but be very useful, by its brilliancy, its hardness, and its unchangeable nature.

The process of Mr. de Lisle to fuse platina, was published in 1774. Mr. Achard published a simpler method, nearly at the same time: it consists in taking two gros of platina, two gros of the white oxide of arsenic, two gros of the acidulous tartrate of pot-ash, and putting them into a crucible well luted. This is to be exposed for an hour to a violent fire, which fuses the platina; but it is brittle, and whiter than ordinary platina. It is then to be exposed to a considerable heat under a muffle; by which means all the arsenic which was combined with the platina is dissipated, and this metal left in a state  
of



of purity. Vessels of platina may be formed, by filling clay moulds with the alloy of platina and arsenic; and exposing the mould in the muffle, to dissipate the semi-metal.

Mr. de Morveau substituted the arseniate of pot-ash to advantage, instead of arsenic; and he had already fused platina with his vitreous flux, made of pounded glass, borax, and charcoal.

Mr. Pelletier fused platina, by mixing it with phosphoric glass and charcoal. The phosphorus then unites with the platina; and the phosphure of platina is exposed to a degree of heat sufficient to volatilize the phosphorus.

Mr. Baumé advises to fuse platina with a slight addition of lead, bismuth, antimony, or arsenic; and to keep the alloy in the fire a long time, to dissipate the metals which have facilitated the fusion.

Platina may likewise be fused with a metal soluble in an acid: the mixture being pulverized, the alloyed metal may be dissolved; and the powder of platina may then be fused with the flux of De Morveau.

Instead of using a soluble metal, a calcinable metal may be employed, and treated as before.

The cubic foot of crude platina weighs 1092 livres 1 ounce 7 gros 17 grains; platina purified



refined and fused weighs 1365 livres; and purified platina forged weighs 1423, 8, 7, 64.

Most of the neutral salts have no perceptible action on platina. The results of several curious experiments may be seen in the *Memoirs of Margraaff*.

The nitrate of pot-ash alters platina, according to the experiments of Lewis and Margraaff. Dr. Lewis, by heating a mixture of one part of platina and two parts of this nitrate, during three times twenty-four hours, observed that the metal assumed a rusty colour. By diffusing the mixture in water, the alkali was dissolved; and the platina, deprived of all the soluble matter, is diminished one-third. The powder taken up by the alkali is the oxide of iron, mixed with the oxide of platina.

These experiments, as likewise the property which platina possesses of being acted on by the magnet, prove that it contains iron; and Mr. de Buffon has concluded that this metal is a natural alloy of gold and iron. But it has been objected that the artificial alloy of these two metals, made in every possible proportion, never resembles platina; that this metal departs more from the properties of gold in proportion as it is deprived of iron: so that it is considered as a truly peculiar metal.

This



This metal is capable of being alloyed with most of the known metals.

Scheffer first affirmed that arsenic rendered it fusible.

Messrs. Achard and De Morveau have availed themselves of this property to fuse it, and compose vessels.

Platina easily unites with bismuth. The result is eager, brittle, difficultly cupelled; and the result is a mass which has little ductility.

Antimony likewise facilitates the fusion of platina. The alloy is brittle; part of the antimony may be disengaged by fire; but a sufficient quantity remains in combination to deprive the platina of its weight and ductility.

Zinc renders this metal more fusible. The alloy is very hard; great part of the zinc may be volatilized by fire; but the platina always retains a small quantity.

This metal unites easily with tin. This alloy is very fusible, and flows clear; it is eager, and very brittle: but when the tin is in a large proportion, the alloy is ductile; its grain is coarse, and it becomes yellow by exposure to the air.

Lead unites very well with platina. A stronger heat is required to fuse this than the foregoing alloy. It is not ductile; is no longer capable of being absorbed by the cupel, the



absorption only taking place when the lead is in excess; but the platina remains always united to a considerable portion of the metal. Nevertheless Messrs. Macquer and Baumé cupelled one ounce of platina and twenty ounces of lead, by exposing this alloy, for fifty hours, in the hottest part of the porcelain furnace at Seves. Mr. De Morveau had the same result in Mr. Macquer's wind-furnace; the operation lasted between eleven and twelve hours. Mr. Baumé observed that the platina obtained by this process possesses the power of being forged and soldered completely, without the assistance of any other metal, which renders it a most valuable acquisition in the arts.

Dr. Lewis could not unite forged iron with platina; but having melted crude iron with this metal, there resulted an alloy so hard that the file could not touch it: it was ductile in the cold, but broke short when hot.

Copper and platina alloyed together form a very hard metal, which is ductile, while the copper predominates in the proportion of three or four to one: it takes a fine polish, and was not tarnished during the space of ten years.

Platina, alloyed with silver, deprives it of its ductility, increases its hardness, and tarnishes its colour. These two metals may be separated  
by



by fusion and repose. Lewis observed that the silver which is fused with platina, is thrown up against the sides of the crucible with a kind of explosion: this phenomenon appears to be owing to the silver, as Mr. Darcet found it break porcelain balls in which it was inclosed, and out of which it was projected by the action of the fire.

Gold is not capable of being alloyed with platina but by the most violent heat; the colour of the gold is prodigiously altered, and the alloy possesses considerable ductility.

We know enough of the properties of this metal to presume that it will prove of the greatest use in the arts. Its almost absolute infusibility, and its unchangeableness, render it of extreme value to form chemical vessels, such as crucibles, and the like. The property of soldering or welding without mixture, renders it preferable to gold or silver.

Its density and opacity render it likewise of great value for the construction of optical instruments; and the abbé Rochon has constructed a mirror whose effect greatly surpasses that of the mirrors before made of steel and other metals. This metal unites two qualities never before found in one and the same sub-



stance. Like other metallic mirrors, it reflects but one single image ; at the same time that it is as unchangeable as the mirrors of glass.

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## C H A P. XVI.

### *Concerning Tungsten and Wolfram.*

**W**E are acquainted with two minerals which may be distinguished by the generic title of Tungsten : the one white, and known by the name of Tungsten, or the Heavy Stone of the Swedes ; the other known by the name of Wolfram by mineralogists. We shall examine each separately.

## A R T I C L E I.

### *Concerning Tungsten.*

Tungsten is a substance of an opaque white colour, very heavy, and of a moderate degree of hardness :



hardness: its crystals are octahedrons. Its specific gravity is 6,0665, according to Brissón; from 4,99 to 5,8, according to Kirwan. The cubic foot weighs 424 livres 10 ounces 3 gros 60 grains.

When exposed without addition to the flame of the blow-pipe, it decrepitates without melting. With soda it is divided with a slight effervescence; is partly soluble in the native phosphate, or microcosmic salt; and affords a fine blue colour, without the least appearance of red in the refracted light, as happens with cobalt. It is soluble in borax without effervescence.

Bergmann affirms that by pouring the muriatic acid upon pulverized tungsten, the powder immediately assumes a fine bright yellow colour. To this character Scheele adds that of becoming blueish when boiled in the sulphuric acid.

This substance has a sparry appearance, and was long confounded with the white tin ore. It is found at Bitsberg, at Riddharhittan, at Marienberg, at Altemberg in Saxony, and at Sauberg near Ehrenfriedersdorff.

Mr. Raspe, in Crell's Annals for June 1785, gave an account of two mines of tungsten in the province of Cornwall, from which thousands of tons might be extracted. This philosopher ob-



tained the metal in the proportion of about thirty-fix livres the quintal. He adds that this metal contains little iron; that it is very fixed, and refractory in the fire; and that it acts on glass like the hardest steel.

Cronstedt arranges the tungsten among iron ores; and defines it to be *ferrum calciforme terrâ quâdam incognitâ intimè mixtum*.

Scheele has affirmed that it is a salt resulting from the combination of calcareous earth with a peculiar acid; which acid, combined with lime-water, regenerates tungsten.

Bergmann considers the acid earth of tungsten as a metallic acid.

Several processes are at present known for extracting the acid of tungsten.

1. Any desired quantity of this mineral is to be pulverized, and fused with four times its weight of carbonate of pot-ash, and poured out upon a plate of metal. The mass is then to be dissolved in twelve parts of boiling water. A white powder separates during the solution, and falls to the bottom of the vessel. This precipitate is a true carbonate of lime, mixed with a small quantity of quartz, and a portion of undecomposed tungsten. The carbonate of lime may be taken up from the precipitate by nitric acid; and the remaining tungsten being mixed with



with the former proportion of carbonate of pot-ash, is to be fused, dissolved, and by a repetition of these operations will at length be totally decomposed. The water in which the fused masses were washed, holds in solution a salt formed by the tungstic acid and the alkali made use of. If this solution be saturated with nitric acid, it seizes the alkali; the solution becomes thick; and a white powder falls down, which is the tungstic acid.

2. Scheele, the author of this first process, proposes a second, which consists in digesting three parts of weak nitric acid upon one of pulverized tungsten. This powder becomes yellow; the fluid is then decanted, and two parts of ammoniac are poured upon the yellow powder. The powder then becomes white; and in this way the repeated actions of the acid and the alkali are applied until the tungsten is dissolved. Out of four scruples, treated by Scheele in this manner, there were three grains of insoluble matter, which was a true quartz. By adding the prussiate of pot-ash to the nitric acid made use of, he obtained two grains of Prussian blue; pot-ash precipitated three of chalk; and the ammoniac uniting to the nitric acid, precipitated an acid powder, which is the true tungstic acid.

In this experiment the nitric acid seizes the



lime, and uncovers the tungstic acid which is seized by the alkali.

The muriatic acid may be substituted to advantage instead of the nitric acid, and even gives it a yellower colour.

Scheele and Bergmann considered this acid powder as the true tungstic acid in a state of purity. Messrs. Delhuyars have asserted that this acid was mixed with the acid made use of in obtaining it, and also with the alkali; they assert that the yellow powder which is uncovered by the digestion of the nitric acid, is the true acid oxide of tungsten without mixture.

The white powder which is obtained by decomposing the alkaline solution of tungsten by an acid, is acid to the taste, reddens the tincture of turnsole, precipitates the sulphure of alkali of a green colour, and is soluble in twenty parts of boiling water.

*Properties of the white powder obtained by decomposing the solution of the ore of tungsten by an acid.*

1. An acid taste, reddening the tincture of turnsole.

2. Exposed to flame urged by the blow-pipe, it passes to a brown

*Properties of the yellow matter obtained by fire or by acids.*

1. Insipid, reddening the tincture of turnsole.

2. Treated with the blow-pipe, it preserves its yellow colour



a brown and black colour, without affording fumes or signs of fusion. colour in the external flame; but swells up, and becomes black, without fusing, in the interior blue flame.

3. It is soluble in twenty parts of boiling water.

3. It is insoluble, but capable of becoming so divided as to pass through the filters.

4. It becomes yellow by boiling in the nitric and muriatic acids, and blueish in the sulphuric acid.

4. The three mineral acids have no action upon it.

From this comparison it appears that the acid is purer in the yellow powder than in the white; and the saline combinations of these two substances have confirmed Messrs. Delhuyars in their opinion.

The yellow acid, combined with pot-ash, either in the dry or humid way, forms a salt with excess of alkali. If a few drops of nitric acid be poured on this salt, a white precipitate is instantly formed, which is redissolved by agitation. When all the alkali is saturated, the solution is bitter; if more acid be poured in, the precipitate which falls down is no longer soluble. This precipitate, when welledulcorated, is exactly of the same nature as the white powder we have spoken of. The experiments of Messieurs Delhuyars, and of Mr. De Morveau, prove very clearly that this white powder contains



the acid of tungsten, a portion of the pot-ash with which it was before combined, and a small quantity of the precipitating acid.

It is therefore well proved that the yellow matter is the pure oxide, and the true tungstic acid. It is likewise very certain that this acid exists ready formed in the metal; and that its oxigene is afforded neither by the decomposition of another acid, nor the fixation of the oxygenous gas of the atmosphere; it appears to exist in the mineral, and to constitute a kind of salt of many principles.

The pure tungstic acid dissolves ammoniac; but the result is always with excess of alkali. This solution affords by evaporation small crystals, of a penetrating bitter taste, soluble in water, and then reddening blue paper. The alkali is easily separated; and these crystals return by calcination to the state of yellow powder, entirely similar to that which entered into its composition. If the calcination be made in closed vessels, the residue is of a deep blue colour; for the yellow colour does not appear unless the calcination be made in the open air.

The experiments of Mr. De Morveau permitted him to class the affinities of this acid in the following order, which is the same as that  
of



of the arsenical acid, lime, barytes, magnesia, pot-ash, soda, ammoniac, alumine, metallic substances.

## ARTICLE II.

### Concerning Wolfram.

Wolfram is of a blackish brown colour, sometimes affecting the form of an hexahedral compressed prism, terminated in a dihedral summit. These surfaces are frequently striated longitudinally. Its fracture is lamellated, foliated, and the leaves are flat, though rather confused. Externally it resembles schorl; but is not fusible, and is incomparably heavier.

Some mineralogists have taken it for an arsenical ore of tin; others for manganese, mixed with tin and iron. Messrs. Delhuyars, who made a strict analysis of it, found it to contain manganese 22, oxide  $13\frac{1}{2}$ , quartzose powder 2, yellow powder or tungstic acid 65.

The wolfram which was analysed by these chemists, came from the tin mines of Zinnwalde, on the frontiers of Saxony and Bohemia. Its specific gravity was 6,835.

Wolfram does not melt by the blow-pipe without



without addition, its angles being scarcely rounded. With the native phosphate, or microcosmic salt, it melts with effervescence, and affords a glass of an hyacinth colour.

It effervesces with borax, and forms a greenish yellow glass in the blue flame. This glass becomes red in the external flame.

Pulverized wolfram upon which the muriatic acid is boiled, assumes a yellow colour like tungsten.

Messrs. Delhuyars fused in a crucible two gros of pulverized wolfram, and four gros of pot-ash. The fused mixture being poured out on a plate of copper, a black matter remained in the crucible; which, when welledulcorated, weighed thirty-seven grains, and was found to be a mixture of iron and manganese.

The mass which had been poured out was dissolved in water, filtered, and saturated with nitric acid. It afforded a white precipitate, absolutely similar to that obtained from tungsten by a similar process.

The process of Scheele, by the humid way, succeeds equally well, and even appeared to Messrs. Delhuyars to be more advantageous. They prefer the disengagement, by mere heat, of the ammoniac which holds the tungstic acid in solution. One hundred grains of wolfram,  
treated



treated with the muriatic acid and ammoniac, afforded them sixty-five grains of yellow powder, which is the pure acid.

This yellow acid powder unites with most of the metals. Messrs. Delhuyars relate the following facts :

1. One hundred grains of gold leaf, and fifty grains of the yellow matter, urged by a violent heat for three quarters of an hour, in a crucible lined with charcoal, afforded a yellow button, which crumbled in pieces between the fingers, and internally exhibited grains of gold, with others of a grey colour. This button weighed one hundred and thirty-nine grains; and was cupelled with lead, though with difficulty.

2. Similar proportions of platina and the yellow matter, treated in the same way (for an hour and a quarter), afforded a friable button, in which grains of platina were distinguishable, of a whiter colour than ordinary. It weighed one hundred and forty grains.

3. With silver, the yellow matter formed a button of a white greyish colour, rather spongy, which extended itself easily by a few strokes of the hammer; but, on continuing them, it split in pieces. This button weighed one hundred and forty-two grains, and the mixture was perfect.

4. With copper, it afforded a button of a  
coppery



coppery red colour, inclining to grey, which was spongy, and considerably ductile. It weighed one hundred and thirty-three grains.

5. With crude or cast iron, of a white quality, it afforded a perfect button, whose fracture was compact, and of a greyish white colour. It was hard, brittle, and weighed one hundred and thirty-seven grains.

6. With lead, it afforded a button of an obscure grey colour, with very little brilliancy, spongy, very ductile, and splitting into leaves when hammered. It weighed one hundred and twenty-seven grains.

7. The button formed with tin was of a lighter grey than the preceding, very spongy, somewhat ductile, and weighed one hundred and thirty-eight grains.

8. The button of antimony was of a bright grey, rather spongy, brittle, and easily broken; it weighed one hundred and eight grains.

9. That of bismuth presented a fracture which, when seen in one direction, was of a grey colour, and metallic lustre; but in another direction it appeared like an earth without any lustre: but in both cases an infinity of pores were seen over the whole mass. It weighed sixty-eight grains.

10. The button formed with zinc was of  
a black



a black greyish colour, and an earthy aspect, very spongy, and brittle: it weighed forty-two grains.

11. With common manganese it afforded a button of a blueish grey colour, and earthy aspect. Its internal part, examined with a lens, resembled an impure scoria of iron; it weighed one hundred and seven grains\*.

These experiments confirm the suspicion of the celebrated Bergmann; who, from the specific gravity of this substance, and its property of colouring the native phosphate and borate of soda, concluded that it was of a metallic nature.

The change of colour which accompanies its reduction, its increase of weight by calcination, its metallic aspect, and its uniting with other metals, are incontestable proofs of its metallic nature. The yellow matter must therefore be considered as a metallic oxide; and the button obtained by exposing this oxide to a strong fire, with powder of charcoal, is a true metal.

\* In Cullen's Translation of the Chemical Analysis of Wolfram, printed in London in 1785, I find the word *brown* in every place where M. Chaptal has used the word *grise*, or *grey*. Not having the original, I cannot speak with certainty; but from circumstances conclude this last to be right. T.



Messrs. Delhuyars having put one hundred grains of the yellow matter into a lined crucible well closed, and exposed it to a strong heat for an hour and a half, found upon breaking the crucible, when cold, a button which was reduced to powder between the fingers: its colour was grey. On examining it with the magnifier, an assemblage of metallic globules were seen, among which some were of the bigness of a pin's head, and when broken exhibited a metallic fracture resembling steel. It weighed sixty grains, and of course there was a diminution of forty. Its specific gravity was 17,6. Having calcined a part of it, it became yellow with  $\frac{24}{100}$  increase of weight. The nitric and the nitro-muriatic acid changed it into a yellow powder. The sulphuric and muriatic acids diminished its weight, and their solution let fall Prussian blue. The metallic grains always remained after the action of these acids. This metal shews various properties, which distinguish it from all others known. 1. Its specific gravity is 17,6. 2. It forms peculiar glass with the several fluxes. 3. It is almost absolutely infusible, much less fusible than manganese. 4. Its oxide is of a yellow colour. 5. It forms peculiar alloys with the known metals. 6. It is insoluble in the sulphuric, muriatic, nitric, and nitro-muriatic acids;



acids; and these two last convert it into an oxide. 7. The oxide combines with alkalis. 8. The oxide is insoluble in the sulphuric, nitric and muriatic acids, and assumes a blue colour with this last.

Wolfram ought to be considered as an ore, in which this metal is combined with iron and manganese, as Messrs. Delhuyar have proved.

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C H A P. XVII.

*Concerning Molybdena.*

**T**WO substances have long been confounded together under the name of Black Lead Ore, Mineral Lead, Plumbago, and Molybdena, which the more accurate analysis of the celebrated Scheele has proved to be of very different nature.

Molybdena cannot be confounded with the mineral of which black lead pencils are made, which is called Plumbago. The characteristic differences are sufficiently evident to leave no doubt on this subject.

Molybdena is composed of scaly particles, either large or small, and slightly adherent to each other. It is soft and fat to the touch, soils the fingers, and makes a trace of an ash-grey colour. Its aspect is blueish, nearly re-



sembling that of lead. The mark it makes on paper has an argentine brilliancy; whereas those of plumbago are of a darker and less shining colour: its powder is blueish; by calcination it emits a smell of sulphur, and leaves a whitish earth. The nitric and the arsenical acids are the only acids which attack it effectually; it is soluble in soda with effervescence before the blow-pipe; it causes the nitrate of pot-ash to detonate, and leaves a reddish residue; when exposed to the flame of the blow-pipe in the spoon, it emits a white fume.

Plumbago is less fat, less granulated, and composed of small brilliant particles. It loses in the fire  $\frac{2}{100}$  of its weight, and the residue is an oxide of iron.

Molybdena has been found in Iceland, in Sweden, in Saxony, in Spain, in France, &c. that of Iceland is found in plates, in a red feldspar mixed with quartz.

Mr. Hassenfratz gave Mr. Pelletier samples of molybdena similar to those of Iceland, which he had collected in the mine named Grande Montagne de Chateau Lambert, near Tillot, where a copper mine was formerly wrought.

William Bowles appears to have found molybdena near the village of Real de Monasterio: it is in banks of grit-stone, sometimes mixed with granite.

The



The molybdena of Nordberg in Sweden is accompanied with iron that obeys the magnet.

The molybdena of Altemberg in Saxony nearly resembles that of Nordberg.

Mr. Pelletier analysed all these species; and his work may be consulted in the *Journal de Physique* for 1785; but the experiments we shall here relate were made with that of Altemberg.

Molybdena, exposed to heat on a test, becomes covered, after the space of an hour, with a white oxide; which, when collected by a process similar to that used with the sublimed oxide of antimony, has all the appearances of this last substance. The whole of the molybdena may by this means be converted into oxide. We are indebted to Mr. Pelletier for this fine experiment, which had escaped Scheele.

Molybdena is indestructible in close vessels, and prodigiously refractory, according to the experiment of Mr. Pelletier, made with balls of porcelain exposed to the most intense heat.

Molybdena treated with the black flux was not reduced, nor even deprived of its sulphur.

Molybdena fused with iron affords a button, which resembles cobalt: it unites likewise perfectly with copper; but when mixed with lead and tin, it renders them so refractory that the results are pulverulent and infusible alloys.



The oxide of molybdena obtained by calcination, or by the action on the nitric acid, is not reducible when treated with black flux, alkali, charcoal, or the other saline fluxes; nevertheless if the oxide of lead or copper be added, the metals which result are alloyed with a portion of molybdena, which may be separated.

The oxide of molybdena made into a paste with oil, dried by the fire, put into a lined crucible, and urged by a violent heat for two hours, afforded Mr. Pelletier a substance slightly agglutinated, which could be broken with the fingers. It was black, but perceptibly of a metallic aspect. When viewed with the magnifier, small round grains of a greyish metallic colour were seen, which are the metal of molybdena. It is prodigiously refractory; for the fire which Mr. Pelletier gave was stronger than that which Mr. Darcet used in the same forge to fuse platina and manganese.

1. Molybdena is calcinable, and passes to the state of a very white oxide. 2. It detonates with nitre, and the residue is an oxide of manganese mixed with alkali. 3. The nitric acid converts it into a white acid oxide. 4. The alkalis disengage hydrogenous gas from it in the dry way, and the residue is the oxide of manganese and alkali. 5. It alloys with the metals in different manners.



ners. Its alloys with iron, copper, and silver, are very friable. 6. When treated with sulphur it regenerates the mineral molybdena.

According to Mr. Kirwan, the mineral of molybdena contains fifty-five pounds sulphur, and forty-five metal. The iron is accidental.

To reduce the mineral molybdena to powder, Scheele directs that it be triturated in a mortar with a small quantity of sulphate of pot-ash. The powder is afterwards washed in hot water, to carry off the salt, and the molybdena remains pure.

This ore is a true pyrites, which, when treated with the blow-pipe, emits a white acid fume. But as this method affords only a small quantity of oxide, another method is used to obtain it. Thirty parts of nitric acid are distilled on one of powder of molybdena; care being taken to use a large retort, and to pour the acid on at several times, having previously diluted it with one-fourth of water. The receiver being luted on, the distillation is performed on the sand-bath. When the fluid begins to boil, a considerable quantity of nitrous gas comes over. The distillation being continued to dryness, there remains a powder, upon which an additional dose of nitric acid is poured; and this management is repeated until all the nitric acid has been used. At the end of the process there remains



mains a residue as white as chalk, which is to be washed with water to carry off a small quantity of sulphuric acid, which is formed by the decomposition of the nitric acid upon the sulphur. After this edulcoration there remain six gross thirty-six grains of an acid powder, when the operation has been made with thirty ounces of nitric acid, and one ounce of molybdena. It is the molybdic acid.

The arsenical acid distilled from the mineral molybdena, likewise affords the molybdic acid.

It is evidently seen that its formation, like that of the arsenical acid, is owing only to the decomposition of the acids made use of, and the fixation of their oxigene on the metal employed.

This acid is white, and leaves a perceptibly acid and metallic taste on the tongue.

Its specific gravity compared with that of pure water is 3,460 : 1,000, according to Bergmann.

It undergoes no alteration in the air.

It does not rise in sublimation, but by the assistance of the air.

It colours the native phosphate of a beautiful green.

If it be distilled with three parts of sulphur, the mineral molybdena is regenerated. This  
acid



acid is soluble in five hundred and seventy times its weight of water at a mean temperature. The solution is very acid; decomposes the solutions of soap; precipitates the sulphures of alkali. It becomes blue and consistent by cold.

The concentrated sulphuric acid dissolves a large quantity of it. The solution assumes a fine blue colour, and becomes thick by cooling. This colour disappears by heat, and returns again as the fluid cools.

The muriatic acid dissolves a considerable quantity by the assistance of ebullition. If the solution be distilled, it leaves a residue of an obscure blue colour. By an increase of heat, white sublimate rises mixed with a little blue; the fuming muriatic acid passes over into the receiver. This sublimate attracts humidity, and is nothing but the molybdic acid volatilized by the muriatic.

This solution of the molybdic acid precipitates silver, mercury, and lead from their solutions in the nitric acid. It likewise precipitates lead from its solution of the muriate of lead, but not the other metals.

The molybdic acid takes barytes from the nitric and muriatic acids.

In the dry way it decomposes the nitrate of potash, and the muriate of soda; and the acids pass over in the fuming state.



It disengages the carbonic acid from its combinations, and unites with the alkalis.

It even partly decomposes the sulphate of pot-ash by the assistance of a strong heat.

It dissolves several metals, and assumes a blue colour in proportion as it yields its oxigene to them.

The combinations of this acid with the alkalis are little known. Scheele however has observed, that fixed alkali renders this acid earth more soluble in water; that the alkali prevented the acid from rising; that the molybdate of pot-ash is precipitated by cooling in small granulated crystals.

The oxigene adheres but slightly to the molybdic base: for this acid boiled with the semi-metals does not fail to assume a blue colour.

Hydrogenous gas passed through it is sufficient to produce the blue colour.

Molybdena, as Mr. Pelletier has observed, has a great resemblance in its chemical results to antimony; since, like that semi-metal, it is capable of affording by calcination an argentine oxide, capable of vitrification.



