LESSONS ON MINERALOGY.

W. M'Dowall, Printer, Pemberton Row,
Gough Square.

A BRAZILIAN MINER WASHING THE ALLUVIAL SOIL (RAKED FROM THE RIVULET) FOR GOLD & DIAMONDS.

VIEW NEAR MATLOCK, DERBYSHIRE.

FAMILIAR

LESSONS

ON

MINERALOGY AND GEOLOGY:

WITH

COLORED PLATES.

To which is added

A PRACTICAL DESCRIPTION OF THE USE OF

THE

Lapidary's Apparatus,

Explaining the Methods of slitting and polishing Pebbles, &c.

BY JOHN MAWE,

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Whose hand unseen the works of nature dooms,
By laws unknown! WHO GIVES AND WHO RESUMES.

FIFTH EDITION.

London:
PRINTED FOR AND SOLD BY THE AUTHOR, 149, STRAND; AND LONGMAN, HURST, REES, ORME, AND BROWN, PATERNOSTER ROW.
1823.

PREFACE.

THE Author, fully aware of the difficulties the beginner has to encounter in reading elementary works on Mineralogy, has carefully avoided tedious details and technical phraseology, studiously aiming at simplicity of description, and concise explanation, that the learner may be led straight forward to the subject, and enabled to discriminate one Mineral from another, the substances that compose the mountains, and the ground on which he treads.

MINERALOGY may be contemplated in two points of view. It may be considered as closely connected with the more common affairs of life, and consequently inviting us to pursue it from its *utility;* or, by affording to us continual examples of regularity—the undeviating order of nature, it may, like Astronomy, accustom the student to sublime speculations, and become the means of enlarging and dignifying the faculties of his understanding.

The possessor of landed estates, the artisan and manufacturer, can all render Mineralogy subservient to their respective advantage, and the object of these Familiar Lessons is to unlock, as it were, a casket of useful knowledge, by easy explanations, and to present to the learner a compendious view of the vast importance of Mineralogy.

The Author, feeling the difficulties which attend any one who attempts to simplify what is perplexed, or disentangle what is complicated, undertakes the present little Work, the result of his practical observations, with diffidence.

Costly specimens are by no means necessary to obtain a competent knowledge of Minerals. A careful perusal of a well arranged collection, not too limited, will benefit the student more than one consisting merely of rarities, purchased at a high sum.

The learner will more readily obtain a knowledge of Minerals by applying the aid of chemistry, which will prove of high importance, and greatly facilitate his inquiries. The acids dissolve the metals, which, when in solution, may be precipitated under various forms and colors. These pretty experiments may be made in small glass tubes or watch glasses, following the directions herein contained.

The aid of the blow-pipe is indispensible ; it is scarcely possible to find words sufficiently strong to convey an idea of the importance and the use of this little instrument, for, by blowing through it across the flame of a candle, such an intense degree of heat is instantly produced, as to melt small particles of Gold, Silver, Copper, &c. when placed on a bit of charcoal, and held in contact with the point of the flame. These experiments are particularly interesting, and so immediately under the eye of the practitioner, that he cannot refrain from observing the changes which take place on the application of heat; the vapors and the color of the slag (more particularly when borax is used) elucidate many important facts; the whole of the materials necessary for such examinations, scarcely occupy the space of a tea-caddy.

DESCRIPTION AND EXPLANATION

OF THE

COLORED PLATE OF MINERALS.

A. Rounded mass of Native Gold .....
a. Granular Gold .....
a. Platina in Grains .....
} Found by washing the soil.

B. Native Silver, in curls .....

C. Native Silver, arborescent, and crystallized .....

No.

1. Native Copper, in branches, with Crystals of Ruby Copper .....
2. Yellow Copper Ore, Blistered Copper .....
3. Malachite, striped, exhibiting its zoned appearance ..
4. Common Cubic Lead Ore ....
5. White, or Carbonate of Lead, acicular and canaliculated crystal .....
6. Green Lead Ore, crystallized in six-sided prisms .....
7. Cubic Iron Pyrites .....
8. Brown, or Liver Pyrites ...
9. Hæmatitic Iron Ore, showing a diverging fracture ...
10. Blende, an Ore of Zinc, in detached and aggregate Crystals .....
11. Calamine, coating a Crystal of Calc Spar .....
12. Emerald Fluor crystallized in cubes, with low 4-sided pyramids on each face .....
13. Barytes, tabular, edges and corners truncated.....
14. Six-sided Crystal of Calcareous Spar, with three-sided apex .....
15. Common Crystal of Calc Spar .....
16. Quartz in hexagonal Crystals .....
17. Garnets, dodecahedron ....
18. Ribbon or striped Jasper...
19. Chalcedony, stalactitic and mammillated .....
20. Obsidian, showing its conchoidal fracture.....
21. Red Porphyry, with White Felspar embedded .....
22. Orbicular Granite .....

J. Mawe, 149. Strand.

FAMILIAR LESSONS

ON

Mineralogy.

LESSON I.

TO explain what is meant by FOSSILS or MINERALS, and to instruct the learner how to distinguish one substance from another, is the subject of the following pages.

Minerals may be defined to be bodies destitute of life and organization; they are dispersed in the earth, and on its surface, and commonly deposited in what are termed veins *(fissures)**, which, when worked, are called mines, whether at the greatest depth we have penetrated, or in the alluvial soil. A distinct piece is commonly denominated a Specimen, and a number of various substances, a Collection.

Mineralogy is the science which has for its object the knowledge of the properties of minerals, and enables us to distinguish them from each other, to arrange and describe them.

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* See Geological Part.

It is true, that this science is not marked by those distinguishing laws, that are the leading features of the Sister sciences, yet a general knowledge may be attained with little difficulty; and although the learner may find his path at first rather clouded and obscure, yet, when the mist is once cleared away, a brilliant display of useful knowledge will be opened to his senses: and by beginning under the following directions, considerable progress may be made in a few days, and afterwards he will be enabled to instruct himself.

To imagine that any one unacquainted with minerals can define and say what they are at first sight, would be as unreasonable as to expect, that an unlettered man should acquire a knowledge of the contents and beauties of classical authors by seeing the title-page of their works.

Without further preface, I will endeavour to point out the most easy method for the learner, who may possess a few Minerals, to discover their properties, and determine what they are, *viz.*

Suppose any one to have a piece of Lead Ore, or shining Yellow Pyrites, and Rock Crystal *(Quartz)*, or Calcareous Spar. These substances are selected as being the most common and generally met with:—further, I will for example suppose him to ask,

How can I satisfy myself that this Specimen is Lead Ore, or this Pyrites (which appears like Gold), and this Rock Crystal, or this Calcareous Spar?

In reply to the first part of the question—Observe its blue color, and remark its great weight, in both of which it resembles Lead; break a small portion, and notice the fragments and their metallic lustre; it will be soft and

brittle if cut with the knife, or if a bit not larger than a pepper-corn be placed on a piece of charcoal, and the flame of a candle be directed upon it by the blow-pipe, it will almost instantly discharge sulphureous vapors, and in less than half a minute melt into Lead, leaving a white and yellow powder upon the charcoal. The experiment being attended with this result, furnishes a decided answer.

*Shining Yellow Pyrites** may be very readily distinguished from any other substance it may resemble, by the application of the knife or hammer. Endeavour to cut the specimen; and if it is Gold, it will be soft, and yield easily to the knife, like lead: or if it be struck gently with the hammer, it will be indented, Gold being malleable; neither of which properties are possessed by Pyrites, which is on the contrary brittle and hard.

And if a particle be placed on charcoal, and acted upon by the flame of the blow-pipe, if it be Gold it will melt, and retain its yellow color; while the pyrites will generally decrepitate, and burn with a faint blue flame, emitting the odor of sulphur, and be reduced to a dark colored scoria, which will be attracted by the magnet; the two latter effects prove that it is a combination of Sulphur and Iron.

* How many, having met with this common substance, both abroad and at home, have treasured it with the greatest secrecy, believing that they had discovered a Gold mine. Brazil, Rio de la Plata, Africa, &c. can testify the mistakes many travellers have made by not being able to discriminate one from the other.—This substance is often called *Mundic*, *Brazil*, or *Marcasite*.

There is, however, another very interesting method of detecting it, which will shew how many beautiful experiments may be made by employing the aid of chemistry. Put a few of the particles into a glass tube, previously containing a little nitric acid, and hold it over the flame of a lamp or candle until it boils; if it be Gold, no alteration will take place; but if not, considerable action, agitation, effervescence, and change of color will be the result, which shews that the substance has been acted upon (dissolved more or less) by the acid; the contents may be thrown into a glass of water, to which if a few drops of the test for iron (prussiate of potass) be added, the liquid will assume a beautiful blue.—The Iron of the Pyrites, being dissolved by the acid, and held in solution in the water, is as it were regenerated, and precipitated in the form of Prussian-blue, after which the water again becomes clear.

This elegant and easy proof cannot fail to give pleasure to the learner, and shews that an useful knowledge of Minerals may be obtained without difficulty, and will not fail to prepare and encourage his mind for other experiments.

I have now to answer the latter part of the question—What is called Spar is one of the most common productions in the mining counties of England, particularly Derbyshire, and is generally understood to be a brittle shining substance, that will burn to Lime; but Spar is not a very definite term, as Crystal *(Quartz)* is called Spar in Cornwall. We have also other varieties, as Adamantine Spar, Felspar, &c.

To know if the substance is *Calcareous-spar* (Carbonate of Lime, or *Rock Crystal* (Quartz), proceed as

follows:—Apply the point of a knife, and if the body is brittle and easily acted upon, and a white powder is produced, it may be persumed to be the former, for the latter cannot be scratched by the knife, and is sufficiently hard to give fire with steel.

I shall now describe a few of the properties of Lime and Quartz. By placing a few fragments of Calcareous Spar on a hot fire shovel, they will become opaque, and burn to Lime, which may be known by its styptic taste; or, by throwing a particle into a glass of water, it will fall to powder with a hissing noise. Calcareous Spar exhibits a smooth, glass-like, shining surface; when broken, the fragments will be of a rhombic form; it effervesces with acids, even with strong vinegar, if applied to it when reduced to powder; when transparent, it has the property, in a high degree, of presenting two images of an object seen through it—whence it has been called *double refracting spar.* This effect may be best seen by placing a pin underneath it, when the two images will appear more or less distant from each other, as the piece of Spar is thick or thin. This singular and pleasing effect has not yet been fully accounted for.

Rock Crystal, when pure, is perfectly transparent, but it is subject to specks and flaws; it occurs, generally, in six-sided prisms terminated by a short pyramid; when not crystallized, it has the appearance of a piece of broken glass, but it is not so heavy; its fracture is generally shining and uneven, often curved: the fragments are very sharp and irregular; heat has no effect on it, unless it be reduced to fine powder, and mixed with potass or soda,

when it melts and forms glass. These substances are the most common in mining districts, and are frequently confounded with each other.

In the following Lessons I shall adopt that arrangement which I consider to be best calculated to afford the learner the greatest facility in acquiring a general idea of Minerals; and I shall endeavour to describe, in the easiest and most concise manner, the distinctive characters of the subjects which will be presented for examination. The arrangement very nearly coincides with that of the "New Descriptive Catalogue."

LESSON II.

GOLD.

HOW IT MAY BE KNOWN, AND WHERE IT IS USUALLY FOUND.

GOLD is generally obtained from the alluvial soil, in small lumps or particles, called grains or Gold-dust, seldom so large as a pea. In Brazil alone, above twenty tons weight are annually procured, which forms a large portion of the circulating medium of Europe. The principal mining district is called *Minas Geraes.*—The reader will learn with surprise that it does not contain one deep mine or one subterraneous excavation! What is there termed a mine, is a peculiar place, the bed of a river or bottom of a ravine, of greater or less extent, where the soil is composed of alluvial matter, consisting of rounded pebbles, gravel, &c. and sometimes containing *Precious Stones,* besides Gold, *of which it is the great receptacle.*

This argues, that the particles of Gold have been disseminated in the mountains, and from the decomposition of the rock, have been washed down by heavy torrents of rain to their present situation. It is common to see Pyrites *dispersed* in Limestone, and I have some speci-

mens where the Gold is so distributed in Jasper and Granite, but they are very rare.

The Gold is found by raking away the alluvial soil from the rock, and submitting it to a process of washing, by which it is freed from the earthy matter and other substances*.

Particles of Gold are sometimes so extremely delicate, as to float on water; another variety is so small that it cannot be separated from the accompanying heavy ferruginous matter without mercury, which, on being strongly triturated, takes up the gold, and amalgamates with it.

In Africa† Gold-dust is an article of commerce, and considerable quantities are exposed for sale. It is often adulterated with such Pyrites that is the nearest to it in color, and not unfrequently with brass filings, which the merchants appear not to know how to detect; and from the want of *this sort* of knowledge, many have suffered great loss. Some of the better informed negroes make a trade of "trying Gold," and are called "Tryers." Merchants and captains pay them particular attention and respect when they are employed on this business, as, from their *slight knowledge* they save their employers from imposition; on these days the poor negro is admitted to the captain's table.

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* See Frontispiece.

† The poor negroes often bring their scanty pittance in the hollow of a quill to sell to the factors.

HOW TO DETECT GOLD DUST THAT HAS BEEN ADULTERATED.

Place a little of the Gold-dust in a glass tube or earthenware saucer, and pour upon it Nitric acid; then hold the glass or saucer over a flame, or upon a few embers, until red fumes (nitric vapors) arise: if it be pure gold the liquid will not become discolored; but if pyrites or brass filings &c. which resemble gold, should have been mixed with it, the acid will become turbid, green, and black, discharging bubbles of air. After the ebullition has ceased, the residue should be washed with water, and acid again poured upon it, when the same effect may be observed; and if the experiment is repeated until all effervescence ceases, it will finally leave the Gold-dust pure*.

PLATINA

IS found also in grains, the same way as Gold; it is heavier than granular Gold; is of a white color, and resembles Silver; hence it is called Platina, the diminutive of

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* The reason of this is, that Nitric Acid dissolves Iron, Brass, &c, but has no effect upon Gold, which can only be dissolved by Nitro-muriatic Acid. — See "*Instructions for Management of the Blow-pipe, Chemical Tests, &c.*"

Plata, meaning Silver in the Spanish language: it is only met with in some peculiar gold-washings in Mexico, and in one or two in Brazil. Its great weight will distinguish it from silver and from all other metals.

SILVER.

AS Silver has been met with in various parts of Cornwall and Devonshire, the learner will naturally desire to know

HOW TO PROCEED TO DISCRIMINATE ORES OF SILVER.

Native or *Virgin Silver*, as it is sometimes called, occurs in delicate curled fibres, of a silk white color, and filling little cavities (nests) in *quartz;* these fibres are tough and flexible, often surrounded by a black, earthy, soot-like substance. It is also frequently branched in strong ramifications, or leaf-like; and penetrating Spar and other substances, in long serrated, wire-like branches, detached or connected, and frequently interwoven, like network. These Silvers have often a fine rich metallic lustre, resembling Tin, but are subject to become tarnished and black by exposure to the atmosphere.

Silver in this state, *Native Silver*, cannot be mistaken after having been once examined: it yields to the knife,

being little harder than lead; it is malleable, and may be indented by the smallest blow of the hammer; it melts into a beautiful white globule.

By due attention to these remarks, Native Silver may be always discovered.

The *Ruby Silver*, as it is called from its red color, is the most beautiful of the ores of this metal. It occurs in a variety of forms, and very frequently in translucent six-sided crystals.

The *Muriate of Silver* resembles horn, and hence it is called *Horn Silver;* it is so soft, that it may generally be indented by the nail: it is extremely easy of fusion, melting even in the flame of a candle. It is a very rich ore, yielding above 70 per cent.

Many of the Ores of Silver are frequently combined with other metals; the following easy experiment will always detect its presence.

If it be a rich ore it will be soft to the knife or hammer, and melt under the blow-pipe with little difficulty; and by repeated fusion with borax, a bead of Silver may be produced; the combinations will be driven off by heat, or be mixed with the borax, forming a slag.

Or a few small particles of the Ore may be put into a glass tube, and a little nitric acid dropped upon them; then hold it over the flame until they are dissolved; after which dilute it with water, and stir it about with a bright copper wire; if any Silver be present, it will cover the wire with a dull muddy substance, which is metallic Silver: or if a drop of muriatic acid or a little common salt be

added to the solution, the Silver will be precipitated in a thick and dull white cloud *.

If the ore contain a large portion of Copper, which is frequently the case, it will shew itself in melting, by coloring the borax green, also by superficially coating the Silver, but it will finally burn away with a green flame if the heat be continued. It may also be precipitated from the solution, by immersing in it a rod of iron, which it will coat with a film of metallic copper.

If the ore contain Lead, it will be more easily driven off by heat, coloring the charcoal a whitish yellow. Other combinations, which are very frequent, as Sulphur, Arsenic, Antimony, and Bismuth, become easily evaporated. The two former may be detected by their smell; and Antimony by burning with a thick white smoke, and Bismuth by leaving a yellow white oxide.

These experiments on the precious metals may be performed with ease and elegance, by merely possessing a few chemical tests.

Silver is very generally distributed, it is found in various parts of Cornwall and Devonshire, and in the Hartz; but the mines of Mexico and Peru produce ten times as much as the whole world beside.

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* Lead also is precipitated by the muriatic salts, but the two metals may be easily distinguished, the precipitate occasioned by the presence of Silver qickly turns black by exposure to light, and is perfectly insoluble in water: that resulting from Lead is not affected by light, is soluble in about 25 times its bulk of boiling water, and also in nitric acid.

MERCURY.

HOW IT MAY BE KNOWN IN ITS NATURAL STATE.

QUICKSILVER once seen, cannot be mistaken, as it is the only metal which is found naturally in a fluid state; it exists in semi-indurated Clay, in sandstone, and other earthy productions; it often occurs in small and large fluid globules, commonly attended with a red substance: large quantities are obtained in the fluid state. The ores, from which the greatest quantity of Mercury is obtained, are called Cinnabar, which, when rich, are extremely heavy, compared with Iron. They are of a light or brown red color; some varieties are dull, others bright and shining. They may always be known, if rich, by their great weight, or from the knife leaving a deep-red streak upon them; or by exposing a particle to the flame of the blowpipe, when the mercury will exhale in white fumes, which may be condensed upon a plate of Gold, as a guinea, or a piece of bright Copper, as a halfpenny, held over the vapor, and it will assume a silvery appearance, which will become brighter the more it is rubbed: the mercury cannot easily be removed, except by burning it off.—Quicksilver, is always fluid in our atmosphere; it may be rendered solid by producing artificial cold.

The ores of Mercury are not generally distributed, but where they are found, they occur in considerable quantity, as at Idria, Almaden, and Deux Ponts.

COPPER.

HOW TO DISCRIMINATE ORES OF COPPER.

COPPER Ores are found in abundance and in great variety; but as it is not my intention in this little work to endeavour to enumerate all their appearances, I shall merely describe the substance generally, and explain the easiest method of detecting it, previously observing, that Copper is not uncommon in its *native* state; in which form it is found massive, compressed in leaves, foliated, branch-like, &c.; pieces of this description are often met with in veins, particularly in Cornwall. This species of Copper so much resembles the general Copper of commerce in color and texture, that it needs no other description.

The ores of this metal will be found to be more or less hard to the knife as they are poor or rich, the best being the softest. There is another method of determining the purity of the ore by placing a small particle of it upon a piece of charcoal, with a little borax, and directing the flame from the blow-pipe upon it, the ore will soon melt, and if it be rich in metal, it will be reduced to a bead of pure Copper, coloring the borax green, or red-brown, or both.

Chemistry also affords a very easy method of detecting the presence of Copper; it is as follows:

Reduce a small particle to powder; put it into a glass tube or watch-glass, with a few drops of diluted nitric acid; if no action takes place, apply a little heat, by

holding it over the flame of a lamp; the ore will then soon be dissolved by the acid, and if a few drops of water be added, and the point of a knife, or any piece of clean iron be immersed in the solution, it will become coated with a film of Copper, should any be present: or the solution may be thrown into a glass of water; and the addition of a few drops of liquid ammonia will communicate to it a beautiful blue color*.

Even water passing through a vein of this metal, often becomes so strongly impregnated with it, that reservoirs are formed to receive it, into which Iron of any description is thrown: after a few days it becomes coated with a strong covering of Copper, which is scraped off, and the Iron again plunged into the water: this is repeated so long as any Copper remains; and frequently by this method several tons are obtained. The metal thus produced is very pure, and used for the finest purposes.

Ores of Copper have commonly a yellow appearance; the poorer Ores much resembling Iron Pyrites; these contain a large portion of Sulphur and Iron, but are softer to the touch of the knife. Those Ores that are richer, are of a Gold yellow color; some are beautifully irridescent, and are therefore called Peacock Copper. These

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* A similar effect will be produced upon an Ore of Nickel; but it may be easily distinguished by adding a little sulphuric or nitric acid to the solution, slightly in excess, when the immersion of a bar of Zinc will precipitate any Copper which may be present, but no effect will be produced on Nickel. Should a dirty mud-colored precipitate take place, it may be found to arise from a mixture of Arsenic and Iron, with which common specimens of Nickel abound.

varieties have a deeper and more flame-like tinge than common Pyrites.

Some ores of this metal have a shining metallic grey lustre, not unlike Iron; and others are earthy black and even soot-like: also ruby colored and brick-red.

The *Carbonates of Copper* are perhaps the most beautiful in the class of metals, their colors are green or azure-blue of various shades. *Malachite* is a massive variety of the former color and is most elegantly marked with undulating zones. In fact whenever the learner meets with a mineral of a blue or green color he may suspect the presence of Copper, and which may always be detected by applying the preceding rules.

The *Phosphates of Copper* are of a dark green color, with black spots: they may be known by their easy fusion, which takes place as soon as the flame is applied, and leaves a brown slag. *Muriate of Copper* communicates first a beautiful blue color to the flame, and afterwards an emerald green.

Ores of Copper, if combined with *arsenical* acid, or *arsenic* may be known by their being easily fused, and giving copious vapors, which smell of garlic.

The before-named substances are amongst those which most generally occur in this country.

IRON.

THE goodness of Providence is displayed in a most wonderful manner by the distribution of this most useful metal.

Ores of Iron present themselves in great abundance, and exhibit a variety of appearances; they may generally be detected by their action on the magnet, which, however, is not observable in some of them, until they have been heated by the flame of the blow-pipe, and the sulphur driven off. An easy method of detecting iron has been already described, (p. 4.).

The most common Ore in England, from which Iron is made, is *Clay Iron Stone*, which may be considered a deposit, and often contains vegetable impressions. It is almost always found near coal, so necessary for melting it. It is one of the most difficult Ores to reduce; and more art and labor are requisite to conduct a small iron furnace, than to melt all the gold produced in Brazil. I particularly recommend to the learner to think how a piece of Iron Ore is worked, so as to convert it into the useful form of a knife, as a subject well worth his attention. So common as this useful metal is, yet how few know the process it undergoes before it can be applied to our wants!

Pyrites, the most abundant of all minerals, is of a yellow color, frequently beautifully crystallized in brilliant groups or detached cubes, &c.; it also occurs massive. It is a combination of Sulphur and Iron, which has before been named. This Ore of Iron is often disse-

minated in fine particles, in Spar, Limestone, and Coal; scarcely any mine is worked where it is not found. Other properties of Pyrites are described (p. 3.).

Clay, Sandstone, and Jaspers, frequently contain a considerable portion of this metal, which gives to them their red or yellow color. In some stages, the Iron is more subject to decomposition than in others, and of course the substance containing it becomes more deeply tinged with brown or yellow. Many indurated, clay-like stones appear ochreous on the surface, but on being broken, they exhibit two or three stages of decomposition, the centre remaining perfect and hard, not having yet been affected by either water or air, whilst the action of both upon the exterior has given it so different an appearance.

The *Hematites* are of a red, black, or brown color, kidney-shaped, and of a fibrous structure; they are extremely heavy and have often a polished metallic appearance; they are sometimes encrusted with a red, dusty matter which soils the fingers. The term was first applied to those varieties which were blood-red, and afterwards to those of similar structure.

There are other varieties of Iron which are granular and compact, as *Loadstone* and shining *Specular Iron Ores;* some have the appearance of aggregated particles of Iron or steel. The beautiful Ore from Elba presents itself in large crystallized groups, of the brightest iridescent colors, and of the greatest splendor.

The *Carbonate of Iron* has generally a glistening pearly appearance, very unlike a metal; its usual color is some

shade of brown. Its weight would be sufficient to make the learner suspect that it was not what it appeared to be, and the application of either of the above-mentioned tests would decide that it was Iron.

Sandy Iron Ores are in great abundance, and occur in alluvial soil, more particularly in rivers and streams bounded by Granite mountains; they always accompany Gold Dust in great quantity.

MANGANESE

IS a substance of a dark color, and earthy appearance, frequently attendant on Iron Ores and ochreous substances. It commonly occurs near the surface, and is used in glass manufactories, and in bleaching.

HOW TO DETECT MANGANESE

Manganese in its general appearance is earthy, brown, or black, soils the fingers when touched, and frequently contains delicate fibres of a bright iron-like lustre. Another variety is striated and acicular, of a metallic appearance and heavy; it is soft to the knife, and may easily be distinguished from any other mineral. It also occurs with earthy substances, tinging them a beautiful rose or pink color.

The following experiments will always discover the presence of Manganese.

Put a small portion, reduced to powder, into a glass, to which add a little muriatic acid, and hold it over the flame of a lamp. If Manganese be present, it will occasion a disengagement of gas (Chlorine), which may be known by its suffocating odor, and by its discharging the color from printed linen previously moistened, held over the fumes.

With the blow-pipe Manganese presents some curious and pleasing phenomena. A very small particle, after being exposed to a red heat, placed on charcoal, with ten times its bulk of borax, and fused by the interior flame, forms a globule of a violet color; suffer it to cool, and gently remelt it, and the color will be found to have vanished. It may be reproduced by again melting it with the exterior yellow flame, or by adding a bit of nitre, which will be best seen by drawing it, while in a state of fusion, into fibres with a pair of forceps. It cannot be reduced to a metallic state by the blow-pipe.

Manganese gives the color to Amethysts, and other beautiful gems. Calcareous spar and quartz derive their pink tinge from it. The dendritical appearances on various substances, and the beautiful moss-like representations in Mocha stones, owe their origin to it. Manganese is common in Devonshire, and worth about 7*l.* per ton. It is of the first importance in making glass. A preparation of this substance is called mineral Chamelion, from its properties of changing color during solution.

TITANIUM

OCCURS under a variety of forms, but generally in slender crystals of a brown or red brown color. A particular variety, which exhibits a beautiful capillary appearance when imbedded in Rock Crystal, is as delicate as hair, hence it is sometimes called Venus's Hair; it also presents itself in a regular form, as thick as a quill; another variety is found imbedded and wedge-shaped.

Menachanite is a variety of Titanium; it is found in grains of a black color, interspersed with sand, and resembles gunpowder. There are other varieties that occur in larger and smaller grains, which are generally affected by the magnet, but less sensibly than the preceeding.

LEAD.

HOW TO DETECT ORES OF LEAD.

THE ores of this metal are both various and numerous; they may readily be detected by the blow-pipe, as has been already described (p. 3.): from the ease with which they are acted upon by this instrument, I particularly recommend the learner to make frequent experiments upon them.

They occur in large or small veins in almost every rock

formation, but principally in Limestone; they generally contain a portion of silver, particularly the ores of Devonshire and Cornwall. The most abundant is the blue variety, from which the lead of commerce is chiefly produced.

Other ores of Lead are white, green, yellow, red &c. which may generally be discovered by their weight they all easily yield to the blow-pipe, and melt into small globules of lead. If a particle of any of them be reduced to powder, and put into a glass tube, with a few drops of diluted nitrous acid, it will be dissolved with brisk effervescence; and if a piece of zink be immersed in the solution the lead will precipitate upon it in a metallic state.

The white ores of Lead become orange and red at different degrees of heat; and some varieties decrepitate (or start from the charcoal) on the sudden application of the flame: this may be prevented by reducing it to powder with a little borax, and applying the heat very gradually.

ZINC.

HOW TO DETECT ORES OF ZINC.

ORES of *Zinc* form two dictinct substances, as *Blende* or *Black Jack*, and *Calamine*, both of which present several varieties, though they form the same metal.

Blende is commonly black, brown, or yellow, of differ-

ent shades; it is massive, and often appears in clusters (confusedly crystallized) upon the surface of other ores; it may be easily cut by the knife, and by scratching it, a lighter colored powder is produced: some of the yellow varieties, when rubbed even with a pen, yield phosphorescent sparks. These Ores resemble Tin, but they are neither so heavy nor so hard, and, by comparison, may be readily distinguished. Under the strong flame of the blow-pipe, Blende evaporates, and goes off in white flakes.

Common Calamine, greatly resembles some of the earthy minerals; it is frequently cellular, not unlike bone; its superior weight will, however, lead to a suspicion of its metallic nature. From argillaceous stones it may be distinguished by its want of their peculiar odor when breathed on, and by not becoming tenacious when moistened: it also effervesces strongly with acids. From the Carbonates of Barytes and Lime it may be known by placing on the back of the hand a particle which has been recently exposed to the blow-pipe; on moistening it, the heat which is evolved under these circumstances by the above-named earths, will not be experienced.

Before the blow-pipe it is infusible, but loses about one-third of its weight; and if the heat be continued, it escapes in white particles. In nitric acid, moderately diluted and warmed, it dissolves with considerable rapidity and effervescence; and if a small quantity of the solution be poured into a glass tube, the addition of a little ammonia will cause a white precipitate, which will be re-dissolved on adding an excess of ammonia. A slip of paper immersed in the solution, and then held within a few inches of glowing coals, will kindle spontaneously soon

after it is dry. On slowly evaporating the solution, the crystals which form will detonate when projected on ignited charcoal: these characters sufficiently distinguish it from other minerals.

The presence of Zinc in any ore may also be known by mixing a small portion of it with a few grains of Copper filings, and a little charcoal; on cautiously applying the flame of the blow-pipe, so as not to volatilize the Zinc, the Copper will be converted into Brass. Should an ore of Blende be used in this expriment, it will be necessary to subject it previously to a moderate heat, to drive off the sulphur.

Calamine occurs in masses, brown, yellow, and green; also crystallized, in diverging transparent crystals, forming elegant groups. It is generally porous and cellular, but sometimes compact; and this species, when struck, yields a metallic sound. Some varieties become electric on being warmed, and are hard enough to give sparks with steel. It is in great abundance in Derbyshire, and other limestone countries; it is used to convert copper in-into brass.

Ores of Zinc are of recent discovery in this country, that metal being formerly imported from China.

A new metal, called Cadmium, has lately been discovered in the Derbyshire Calamine.

A very pretty experiment is performed with a small particle of Zinc, which, though generally known, I will detail, for the purpose of shewing the great affinity it has for lead.

Example. Lead is acted upon by vinegar, and forms acetate or sugar of lead, which, when dissolved in water,

leaves a white precipitate. If a piece of Zinc be suspended by a thread, and immersed in the fluid, it will be covered almost instantly with the finest flakes of lead, regenerated in its metallic state, which may be seen approaching it in all directions.

This beautiful, amusing, and instructive experiment, cannot sufficiently be admired; it is a lesson upon attraction and affinity, which cannot fail to please those who have not heretofore seen it performed.

LESSSON III.

TIN.

ITS GENERAL APPEARANCE, AND METHOD OF DETECTING IT.

TIN may be detected by digesting a portion of the Ore in muriatic acid, and adding a few drops of muriate of gold, which will produce a purple precipitate: it is essential that both the solutions should be fresh prepared. The muriate of gold may be readily formed, by putting a little gold-leaf into a glass tube, with a small quantity of muriatic acid, and adding nitric acid, by a few drops at a time, until the solution is effected; it will be facilitated, by exposing the tube to a moderate heat, over a spirit lamp.

The general use of *Tin* naturally presents itself to the notice of the teacher; it is not so much distributed as many other minerals, but its ores exist in abundance wherever it has hitherto been found. It is one of the heaviest minerals and one of the lightest metals. It consists of few varieties, which may generally be known by their great weight; it is sometimes of a resinous color, but commonly approaching black; its crystals occur in groups, presenting planes, often intersecting each other, which

mostly have a high lustre. It is hard, and with difficulty scratched by the knife. It forms veins, some of which are delicate, and not thicker than the blade of a knife. It is also met with in alluvial soil in small, heavy, nodular pieces, having diverging striæ, and a ligneous appearance; hence called Wood Tin.

The ores of this metal are not easily reduced; but after being exposed to a red heat, they should be pulverized, and mixed with soda and charcoal, then exposed to the blow-pipe on a clay support, when minute globules of Tin will appear. Care must be taken not to continue the heat, or the Tin will be reduced to a white powder. The same ore, melted with glass, will produce an opaque enamel.

Ores of Tin resemble ores of Iron in some cases, as well as ores of Blende; but are harder, and much heavier and cannot be mistaken, after observing the preceding description.

Tin associates with Blende and Fluor, and sometimes with Copper, but not with Lead or Calcareous Spar: it is considered as one of the oldest metals, and discovered only in the Primitive Rocks, Granite and Clay Slate. It has not been found in any part of this kingdom except Cornwall and Devonshire!

BISMUTH.

THE use of this metal is rather confined; with Tin, it forms a soft solder, which is used by glaziers; it is also a constituent of Pewter.

Bismuth is a metal that is not malleable: it is found in a native state, but more generally combined with Sulphur, and sometimes accompanied by lead.

It has a peculiarly agreeable metallic appearance, of various colors, generally resembling the hue of a Pigeon's Neck, changeable as the light strikes it; which peculiarity may serve to distinguish it from granular Lead Ore. It is soft, and melts the moment it receives the flame, into a white globule; which, if the heat be continued, volatilizes, leaving a white deposit on the Charcoal.

Bismuth frequently accompanies Ores of Silver, Cobalt, and Nickel; and, as its varieties are very few, the learner will be enabled to determine them, after having discerned their peculiarities, by comparing them with other metallic substances.

TELLURIUM.

TELLURIUM is a whitish colored shining mineral, disseminated superficially, in small and delicate leaves and

fibres, of a polished steel color, often appearing map-like, and from this character it is named Graphic Ore.

It is sometimes yellowish, and there is a variety that approaches to black; the latter is rich in Gold, and occurs in larger foliæ: they both yield to the knife, and a bead of Gold may be obtained from the richest variety, by melting it with borax. The Graphic variety cannot be mistaken, and the others may be easily discriminated.

Tellurium is of rare occurrence; it commonly contains Selenum which may be detected by exposing a particle to the flame of the blow-pipe, when it will emit fumes having the odor of horse-radish. It is found in Transylvania.

ANTIMONY.

HOW THE ORES OF ANTIMONY MAY BE KNOWN

Antimony is much used in making Printer's types, in Medicine, and other purposes. It may always be distinguished from Galena by being much lighter.

It does not form so many varieties as several of the preceding. It frequently occurs in long thin crystals, like needles, diverging from a centre, and of beautiful irridescent colors. It has sometimes a shining bright appearance, resembling Lead Ore; but it more commonly occurs of a dull, metallic grey color, compact, or composed of acicular fibres. The massive variety is sometimes covered with a yellowish ochre, arising from the decomposition of the metal, which is not the case with Ores of

Lead. Antimony is soft to the knife, and very brittle. The flame of the blow-pipe will immediately detect it, as it melts the instant it is exposed to heat, and then appears as a dark-colored slag or scoria, swelling and burning entirely away in white fumes.

MOLYBDENA.

MOLYBDENA is a Mineral not very abundant, though it occurs in many situations; it is generally in small foliated patches, of a lead color. It greatly resembles Tellurium, but its leaves are more flexible, and it crystallizes in six-sided tabular plates; it does not melt under the flame of the blow-pipe. It also much resembles plumbago, (common black lead), but may be distinguished by its marking porcelain or earthenware with a greenish streak.

It is commonly imbedded in quartz. It is considered to be one of the oldest metals, and always occurs in the primitive rocks.

Its use is very confined. By being distilled with Nitric Acid a brownish powder is obtained, which is called Molybdic Acid.

COBALT.

HOW ORES OF COBALT MAY BE KNOWN, AND THEIR USE.

THE metal called *Cobalt* gives the beautiful blue color to China and earthenware, and is much used in enamel painting.

The *Ores of Cobalt*, like many of the preceding, consist of several varieties, some of which are rich, and yield a great quantity of coloring matter, which is highly valuable; others again are too poor to pay the expense of being worked. The Ores are generally combined or accompanied with a large portion of arsenic. They have a whitish grey color, and metallic lustre, sometimes tarnished, and approaching to black; they are very heavy, and much harder to the knife than lead ore, which they in some degree resemble.

On examination, some of these ores will be found to have more or less intermixture of peach-red efflorescence; others are dark, earthy, sometimes of various colors, from intermixture of other metals, as black, blue, and green; the latter varieties often occur in Sandstone. The best Cobalt is produced from the Swedish ores.

A very small particle, placed under the flame of the blow-pipe, generally emits fumes of arsenic, after which, if it be reduced to powder, and a little borax melted with it, a deep colored blue glass will be produced. Cobalt, melted with Silex, is called smalts.

The Ores of this metal occur in Mica Slate, and frequently in detached splendent crystals, of a white metallic lustre; generally in cubes or octahedrons, variously modified. Many amusing experiments may be made with Cobalt, which Parkes's excellent Chemical Catechism explains.

Cobalt has also lately been found in Clay Slate in Cornwall, and in the alluvial soil in Cheshire, accompanied by Copper, Manganese, and Lead.

NICKEL.

NICKEL is a metal less known than any of the preceding; but, if the learner has carefully examined the characters of the metals which have been already described, he will be in no danger of confounding it with any of them. It contains above half its weight of Arsenic, and is often called Kupfernickel, (Copper Nickel). It is found combined with Meteoric Iron, and associated with Copper.

Nickel is massive and compact, not so dark as Copper, though approaching to it. It is hard, not easily scratched by the knife, and is very heavy; any further description would avail little or nothing, as the characters before described are sufficient to distinguish it from any other substance. It produces a fine apple-green color in nitric acid. It melts rather difficultly, emitting arsenical fumes that smell like garlic. From this description the learner

will not confound it with the metals that it is often associated with.

Copper, alloyed with Nickel, forms a compound metal resembling Gold, which is called Petit Or.

ARSENIC.

HOW TO DETECT IT.

THIS powerful metallic poison may easily be known by its rapid volatilization, and by the odor of garlic which it emits when heated, or even when struck with a hammer.

It presents great diversity in appearance—when it occurs in a *native* state it has a tin-white color, with metallic lustre. The Sulphuret of Arsenic, called *Realgar*, is scarlet or orange red; it is extremely friable, and melts in the flame of a candle: another variety *(Orpiment)* has a lively yellow color.

The oxide of Arsenic may be considered to be an efflorescence or formed by sublimation; it has generally a white or grey appearance. This is the substance usually known by the name of arsenic; and when we consider its violent effects upon animal life, we cannot but recognise the goodness of the Creator in rendering it so scarce a mineral.

TUNGSTEN.

HOW IT MAY BE KNOWN.

TUNGSTEN, *(Tungstate of Lime)*, is a heavy, opaque, white-colored mineral, sometimes yellowish brown; it often occurs in fragments, is very compact, and may be known by its great weight; it differs from massive Carbonate of Lead, by being harder, and not effervescing with acid.

Wolfram is a common mineral in Cornwall, though hitherto of very limited use. It is of a dark color, approaching to black; hard and brittle, and has a foliated fracture. It yields a *red brown* streak to the knife, and is extremely heavy. It differs from Ores of Tin and Iron in these particulars, and is one of those Minerals of which words cannot convey a perfect idea to the learner. It is rarely met with, except in the countries which produce Tin; it is a Tungstate of Iron, consisting of Tungstic Acid, Iron, and Manganese.

These two substances are often united in the same specimen; they are by no means of common occurrence, and their use is extremely confined: for more particulars the reader is referred to the New Descriptive Catalogue, or some Elementary Work.

URANITE.

URANITE cannot be mistaken for any other substance, if its characters are carefully examined. It is of a beautiful grass green color, rarely yellow green, and generally appears in tender, delicate, leaf-like, quadrangular crystals, which, uniting together in clusters, often present a surface half an inch or an inch across. It sometimes occurs in an ochreous state, both green and yellow; another variety, called *Pitch Ore*, is black, and often accompanied by the ochre; it is extremely heavy, and of rare occurrence.

Uranite has been plentifully found in Cornwall lately; it forms very beautiful specimens, which are of considerable value.

TANTALUM—COLUMBIUM.

THE two following varieties are of late discovery.

Tantalite generally occurs imbedded in granite; it is of a black color, sometimes streaked, and greatly resembles Wolfram and Ores of Iron, but its streak is *brown* or grey, and it is not magnetic. It consists of Tantalum, Iron, and Manganese.

Yttro-tantalite—Yttro-columbite, is found imbedded in

angular fragments, but more generally forming concretions of a black color; it is nearly allied to the preceding; it consists of the new earth Yttria, Oxide of Tantalum, and Oxide of Iron.

These substances are extremely rare, and their uses hitherto so very limited, that I did not, at the commencement of this work, mean to have given them, nor the following, a place in it.

CERIUM.

A NEW metal, which is also of late discovery.

Cerite is of a red brown color, dull appearance, and moderately heavy; it melts partially under the blow-pipe, and forms a dark scoria, which is attracted by the magnet; it consists of Oxide of Cerium 50, Iron, and Silex.

Orthite, Fluate of Cerium, and other varieties of Cerium, are but little known.

CHROMIUM.

CHROMIC acid occurs combined with Lead and Iron; hence Chromate of Lead and Chromate of Iron.

CADMIUM.

A NEW metal, resembling Tin, lately discovered in an ore of Zinc, from the Hartz.

The late Doctor Clarke, of Cambridge, has also found the same metal in a peculiar variety of Calamine, from Derbyshire.

WODANUM

IS also a new discovery, with which we are but little acquainted.

SELENUM

IS a late discovery, and said to be obtained from the Copper Pyrites, from Fahlun in Sweden.

Selenum is suspected to exist in other minerals, but its rapid volatilization renders it difficult to be detected. Its presence may be known, by the fumes having the odor of horse-radish.

OBSERVATIONS ON THE VEINS AND METALS.

AFTER having enumerated the metals in the preceding Lessons, and endeavoured to explain, in a concise manner, how they may be known, a question very naturally arises, viz.

HOW ARE THEY FORMED?

By the term vein is meant a fissure, separating the rock or strata, and filled with Metallic Ores, Crystallizations, &c. differing from the rock in which the vein is situated. These fissures in rocks must have existed prior to their becoming filled with minerals, but in what manner they have been deposited in these receptacles, is yet considered doubtful: there are numerous objections to the theories hitherto advanced. However, it may not be improper to state the following observations relative to some Minerals which appear to be formed by aqueous deposit, and others that exhibit characters of being produced by sublimation, having first premised a description of the veins in which they are found, and of which there are many varieties. Some appear to have been fissures of great extent, taking a direction nearly east and west; these are considered the richest mines, and are worked with the greatest profit; they are also supposed to be the oldest. Others again, called cross veins, run nearly in a north and south direction, and are of less importance than the former, yet some good mines

are also worked in them. Whether these rents have been formed by desiccation, or by natural convulsions (perhaps by both), philosophers are yet in the dark.

Veins differ in their magnitude and position; some are from sixty to a hundred feet wide in some parts, and not more than ten or twenty in others; these are commonly filled with what is called vein stuff, mixed with the metal; others are only a few inches wide. In the primitive rocks, the veins containing metal are commonly associated with Quartz, Pyrites, and sometimes Fluor, rarely Calcareous Spar; in the Secondary and Floetz formations, the metallic veins are filled with Calcareous Spar, Barytes, Fluor, Blende, and Pyrites. The Lead Ores in the primitive rocks contain a much larger proportion of Silver than Lead Ores in the metalliferous Limestone of the Floetz formation.

The veins before stated, considered as fissures or rents, are not perpendicular, but incline more or less, and are often open from the surface of the earth down to twenty or thirty fathoms. However, these are not the only repositories for metals; there are other deposits reverse to the preceding, which are called flat or *pipe veins*; where the solid rock forms the roof and bottom of the mine; these are deemed irregular in their direction and magnitude, having an appearance like a series of small caverns, connected with each other. The top, bottom, and boundaries are lined, (and sometimes filled), with Spar, Lead Ore, and its attendants, Fluor, and Barytes; some of these have produced a vast quantity of both Lead and Copper.

Derbyshire presents great variety; the high mountains and deep ravines exhibit the strata, the stratification, and the veins, in a most instructive manner, parti-

cularly in the neighbourhood of *Matlock*. It is worthy of notice that Lead Ore is met with in *nests* (filling cavities) in solid Limestone: it is even found penetrating the entrochite and fossil shells!

It should be considered that Lead is below the Coal; the Coal formation is generally composed of various sorts of grit, which lie above the Metalliferous Limestone, and is allowed to be a later formation.

Iron seems to be so universally distributed, that there is scarcely an earthy substance into which it does not enter, and is the principal means and cause of their becoming decomposed.

Pyrites (*Sulphur* and *Iron*) is the most abundant substance in the mineral kingdom. I do not remember to have seen a mine without its presence, from the oldest to the newest formation, particularly in Coal; it is also often disseminated in rocks.

There can be no doubt that the ores of some metals are continually forming, as Calamine and Manganese; the former is often found cementing fragments, and coating recently fractured Calcareous Spar, and the latter may be observed deposited in newly made water courses.

Carbonate of Lead, accompanied by Galena, has been found, forming Stalactite, which shows that they were held in solution. It is well known, that several metallic ores, with their associates, line the roofs and sides of caverns; which are evidently deposited by infiltration.

May it not be supposed, that the formation of Metals has been greatly influenced by the simultaneous action of *gravity*, *attraction*, and the *electric fluid*.

That Metallic substances have existed in vaporous exhalation is equally certain,* from the quantities which have been met with, formed by sublimation. The great operations of Nature in her vast laboratory are much beyond the limited comprehension of man; however, by stating the circumstances which have occurred within our own observation, it may be preparing the way for the learner to make more attentive researches, which may lead to important discoveries.

The Rocks in which these Metallic repositories are situated, whether of Granite, (the primitive order), or the more recent formation, (Mountain Limestone), do not, on analysis, contain a particle of the metal which they inclose! Metals are frequently imbedded in Rock Crystal, Calcareous Spar, Barytes, &c.; it is not easy to imagine that Silver, Antimony, or Titanium, &c. in tender and delicate capillary fibres, could force their way through substances so much harder than themselves: therefore, may it not be supposed, that these metallic filaments were first formed, and afterwards enveloped? Minerals obey the universal and most powerful laws of nature—Atraction and Affinity; therefore, it may be fair to suppose the possibility of their having existed together, and afterwards, simultaneously influenced, separated, and become crystallized, each after its own peculiar laws.

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* As Ores of Arsenic, Antimony, Zinc, Mercury, &c

REMARKS.

HAVING given this brief description of the Metals, it may not be improper to say something relative to the situation they respectively occupy in the Earth, before they are extracted from it, and afterwards subjected to those necessary operations, in order to become useful.

GOLD often occurs in a foliated form, in Transylvania and Siberia, in veins filled with other substances, also laminated, imbedded, crystallized, and disseminated: rounded lumps of it, as well as minute particles called Gold dust, have been found in the alluvial soil, all over the world, more particularly in South America, and Africa. It must be remarked that the soil, nearest to the rock, (immediately upon it,) is richest in the precious metal.

Native Gold varies greatly in its purity; sometimes it is found containing one fourth part of Silver or Copper, or both, and never quite pure. It is always, when granular, attended by ferruginous matter, particularly sandy Iron Ore.

Throughout the Gold district of Brazil, I did not see one vein of Gold; and although that precious metal may sometimes appear in short ramifications, in quartz, yet I never saw or heard of any thing like what is understood by a vein, of any regular continuance, filled with Gold *.

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* The author possesses a specimen of Gold above 10 oz. in weight; also the finest Crystals of that substance hitherto seen.

The most productive mine was in the allûvial soil, under a small bed of Micaceous Iron Ore, where a thin stratum of Gold, in delicate foliæ, was intermixed with it.

Platina, though more rare, is found in the same manner.

Silver—Native Silver, and other Silver Ores, occur with Quartz, Calcareous Spar, &c. filling fissures (veins) in the stratum, also accompanying other metals, and not unfrequently combined with them. Silver is often rich in Gold, and Gold frequently contains Silver. In the North of England, and more particularly in Devonshire and Cornwall, the Lead Ore contains a considerable proportion of Silver, which is extracted from it. Some varieties of Ore have produced above a hundred ounces of Silver in the ton of Lead. The Lead Ore is accompanied with Fluor Spar, filling and forming what are termed veins, in which are made excavations to great depths, and the produce brought to the surface by means of mechanical power, as steam-engines, &c.

The principal mines of Silver are in Mexico, Potosi, and Peru, where above forty millions of dollars have been annually coined.

Ores of Silver are of late discovery in Cornwall, as are Ores of Cobalt; both these valuable metals have been thrown away until latterly, when, Mineralogy having become more attended to, minerals have been better understood: and at present one mine is producing annually upwards of £10,000, in Silver.

Tin, Copper, Lead, &c. are extracted from veins of larger or smaller magnitude. These Ores are frequently very difficult to obtain; in many cases they require a

great deal of skill, and extremely hazardous labor. After they are brought from their subterraneous abode, they are dressed, that is, broken in small pieces, and separated by the tedious process of washing from the earthy substances which adhered to them, and ultimately submitted to the furnace, before they can be presented in a useful state. Ores of Tin are found only in Cornwall and Devonshire.

It will appear singular, that although Cornwall has been known as a mining county above two thousand years, yet no notice was taken of Ores of Copper that were met with in working for Tin, until the beginning of the last century.

How confined must then have been the knowledge of minerals amongst the owners of mines! Thousands of tons of this valuable material remained unnoticed, or served only to mend the roads. Since that epoch, perhaps not less than £100,000,000 sterling have been produced from the Copper Ores of Cornwall!! and at a rude estimate, Cornwall produces at present above a million annually in Copper.

So little were the Ores of Lead known (except the common blue lead ore) in our time, that both white and green ores of that substance have been for years lying neglected in heaps both in Derbyshire and Wales, which have since been turned into a very profitable account; nay, of late years, a road repaired with White Lead Ore and Calamine, has been taken up and smelted!!!

Copper Ores occur most abundant in Granite and Clay Slate, particularly in Cornwall, where they are associated with Quartz; but the great mine of rich Cop-

per, at Ecton, in Derbyshire, is situated in Limestone, and is attended with Lead Ore, Blende, Calcareous Spar, and Fluor.

Veins of *Tin* occur only in the older or primitive rocks, as Clay Slate and Granite (consequently it is considered one of the oldest metals), as has been before stated. In some places it is mixed with, and forms a part of the alluvial deposit, from which great quantities have been washed. In the Island of Banca a stratum of Tin Ore lies below the alluvial soil in the valleys, which is worked at an easy rate, and is productive of great profit. This metal may have existed in a massive bed, or have been formed by deposit from the alluvium.

The most instructive collections for beginners are composed of those minerals which are in general use, and commonly met with. It is necessary to observe that the metals present great variety, which must be seen and examined before their characters can be so known as to enable the learner to discriminate them from each other.

The student, after having perused these pages, will be induced to reflect on the importance of Mineralogy. Many kingdoms owe their wealth and greatness to their mineral productions, and individuals innumerable have been enriched by the produce of mines. The washing the alluvial soil, whether for Gold or Tin, is immaterial, if it is advantageous. The Coal we possess is the foundation of our national strength, as well as of our riches, and worth to England more than all the Gold mines of

Peru, which it has rendered subservient to our manufactories.

Independent of every other consideration, it cannot fail to be gratifying to the mind, although not interested in the pursuit of Minerals, to be able to recognise the Rocks and Metals, as Granite from Limestone, or Lead Ore from Copper.

Even this information would, in many instances, have proved of importance, as Limestone has often been transported to various places abroad, where it has since been discovered on the spot. Slag has been bought for Copper, and Tin for Silver, by early visitors to South America*.

It is unaccountable that the component parts of mountains, the great features of the globe which we inhabit, have hitherto been generally unnoticed and disregarded even by those who are deeply interested in the productions of Mines.

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* It is a well-known fact, that, so eager were many needy speculators to buy gold-dust, they absolutely purchased the filings of brass kettles at £3 per oz. which they had sold the day before at two shillings per pound.

LESSON IV.

ON THE ROUNDED PEBBLES USUALLY MET WITH ON THE SEA-COAST, GRAVEL, &c.

HAVING in the preceding pages described the different varieties of Metals, as they are found in the earth, and their application to the various uses of man; I purpose to devote this Lesson to an examination of the substances that are the subject of our constant observation, that form the soil upon which we tread, and the gravel upon our roads. These substances are generally siliceous, and consist of rounded pieces of quartz, jasper, chalcedony, &c, which will be described in order.

How many have gathered small pieces of transparent Crystal, believing them to be Diamonds!

As it is well known that Diamonds cut glass, many imagine that a Crystal *(Pebble)*, gathered from these sources, hard enough to *scratch* it, and to shine when polished, must either be a Diamond, or something related to it! This is not to be wondered at, when it is considered how few have seen rough Diamonds, or have

ever given it a thought, that there is a difference between *scratching* and *cutting glass*.

To prevent, therefore, the learner from being deceived by these appearances, I shall endeavour so to describe the properties of the Diamond, that he cannot be in danger of confounding any other substance with it.

ON DIAMONDS.

THE Diamond, properly applied, acts so extraordinarily in cutting glass, that however thick the plate, it frequently separates in the operation, as if cut asunder; whereas other substances merely scratch it, and do not produce any other effect. Rock Crystal, compared with Diamond, is not so heavy by about one-third. Large Diamonds are extremely rare, therefore those generally offered for sale, in the rough state, from Brazil or India, are rarely the size of a small hazel-nut, but commonly considerably less; they have almost always a *sort* of shining metallic lustre and a crystalline form, exhibiting planes and angles different from those of any other substance.

The beginner, without confining himself to these marks of distinction, may procure a fine file, and rub the substance with a little pressure: if it be a pebble, the file will with difficulty leave an impression—if it be small, place it betwixt two penny pieces, and strongly press them with the thumb and finger, when it will break and be reduced to powder if it is not a Diamond; or it may be tried on

a lapidary's wheel, and the crystal &c. will be instantly worn, but no effect will be produced on the Diamond.

White Topaz, Minas Nova, White Sapphires, and Chrysoberyls, resemble Diamond more than Crystal; but the Diamond cuts them with great ease, nor will they resist pressure betwixt two penny pieces.

Diamonds may easily be known from stones which are cut and polished so as to resemble them. The light will pass through the Crystal, paste, &c.; whereas, in the Diamond, the rays are refracted to the surface, which gives it the highly marked rank it holds in society, and is the cause of its transcendent brilliancy, which fascinates the eye of the most distant beholder.

After due attention to these remarks, transparent substances will not be mistaken for Diamonds.

We shall now proceed to describe the substances which form the alluvial soil: they are generally hard and siliceous, as Quartz and Crystal, already noticed. They all give fire when struck against steel, do not yield to the knife, and when broken, have generally a shining, curved, or uneven fracture; the fragments are splintery and sharp edged. Their general characters may be considered as follows:

JASPERS

ARE very numerous, and consist of great variety; some are much interlinked with Agate, although their general formation is different. Jaspers are of many colors, as

brown, red, yellow, green,&c.; they often form a part of Agate in red stripes and angular lines, blotches, spots, dendritic and moss-like appearances; also curious resemblaces of *Lusus Naturæ*, some of which are highly valued.

Jasper is of a fine texture; exterior appearance, smooth, and often strongly colored, red, yellow, &c.; it is very tough and difficult to break, and contains a large portion of Iron, particularly the red variety.

CHALCEDONY

OFTEN occurs rounded amongst the pebbles of the sea shore: it is of very close texture; fracture, not shining; color generally pale milk blue; is often marked by straight white lines parallel to each other, and frequently resembles white carnelian.

AGATE

IS a substance so generally known, as to need but little description: many are particularly beautiful when cut and polished. Agate commonly consists of Chalcedony, Quartz, and Jasper, in angular and concentric lines; the Crystals of Quartz, frequently lining cavities, serve to shew that the exterior was formed first, and that they

have been filled by a siliceous deposit in solution at distant periods, and owe their color to iron, or manganese. The exterior of Agate is rough and spheroidal, often indented, and generally of a dirty green color.

A mere sight of these substances will impress the mind of the learner so that he will not need more information than that of comparison.

Many collectors have a small lapidary's apparatus for cutting and polishing Pebbles, which will perform all the operations; it is also extremely useful for polishing shells, &c. and so portable that it may be set on a parlour table, and used with great facility.

Rounded pieces of *Granite*, *Green Stone*, and *Porphyry*, occur less frequently in this situation, though they are not uncommon, therefore it may not be improper to notice them in this place.

GRANITE

IS composed of three distinct substances, viz. Mica, Quartz, and Felspar, which the learner will easily discriminate, after once having had the substances pointed out and explained. (See Granite.)

GREEN STONE

IS composed of Hornblende and Felspar: it is generally hard, and of a dull green color, often spotted. Hornblende is both light and dark green, and often gives the same tinge to Felspar, but is not so hard.

PORPHYRY

IS a substance that equals Jasper in hardness, and is generally of a brown or red brown color, speckled with whitish spots; these spots are very seldom round, almost always angular. Porphyry is often met with in a decomposing state; it then is much softer, and finally becomes Clay.

Limestone, *Slate*, *Sandstone*, and semi-indurated *Argillaceous* substances, rarely occur in *Gravel*, or amongst the Pebbles of a surf-beaten coast; because they are not sufficiently hard to resist the action of attrition, and are soon broken down, forming sand and dust.

A little thought on these substances, after examining and looking at them with attention, will convince the learner that he is making some progress, and he will feel pleased at being able to proceed with greater facility.

LESSON V.

GEOLOGY.

DESCRIPTION OF THE VARIOUS EARTHS THAT FORM THE SURFACE OF THE GLOBE.

EARTHS are commonly understood to be composed of substances neither metallic nor inflammable, though many of this class contain various proportions of the former, particularly Iron, and some are combined with the latter.*

The beginner must inform himself of the names of those substances generally called *Earths;* they are but few, and those most commonly met with are only five, viz. *Siliceous, Calcareous, Argillaceous, Magnesian,* and *Barytic;* to which is added the *Strontian.* None of them have hitherto been met with in a state of purity, being

* Recent experiments have tended to show that the Earths are compounds, and that some are considered to have metallic bases.

always associated with one or more substances, either chemically combined or mechanically compounded.

These I purpose to treat of in the following pages, and endeavour to explain their general characters, and the peculiarities which may distinguish them from each other in the common state of their ordinary appearances.

There are four other Earths which are very little known, viz. *Zirconia*, *Glucina*, *Yttria*, and *Thorina;* but these seldom occur, and the beginner, who is desirous to know more of them, may consult an elementary work*.

The surface of the globe, mountains, valleys, the bottom of the deep, and the whole united mass of the Terrestrial Orb, are comprised in the universal term EARTH, and are believed to be chiefly composed of the four† first named, blended or combined in all the degrees and forms in which the Infinite Power, who created it, has thought fit to present it to our view.

As siliceous substances are supposed to be in greater proportion than any of the others, I will endeavour to shew how they may generally be known.

Siliceous Earth or Silex‡ occurs in great abundance in GRANITE, which is composed of QUARTZ, FELSPAR,

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* *Braytes*, *Strontian*, *Zirconia*, *Glucina*, *Yttria* and *Thorina*, are of very limited use: the first is not uncommon in this country, the next may be said to be seldon met with, and the four others are of rare occurrence. Zirconia exists in the Zircon. Glucine exists in the Emerald, Beryl, and Euclase; Yttria, in the Gadolonite; and Thorina, in Cerium.

† *Siliceous*, *Calcareous*, *Argillaceous*, and *Magnesian*.

‡ Silex, Lat. Flint. The word Silex has given way to that of Quartz, which will in future be used indiscriminately in this treatise.

and MICA. These substances are sometimes distinctly crystallized, but generally confusedly aggregated; they are understood to have been the first chemical deposits, when earth obeyed the ALMIGHTY FIAT, and separated from chaos.

" Thy voice retiring Chaos heard,
" And trembled at the potent Word."

GRANITE.

GRANITE forms the highest mountains, some of which are the most rugged and peaked that have hitherto been explored, also the general course of Alpine countries; and the deepest ravines*, having frequently immense tracts of various formations betwixt its lofty points, forming mountains of different elevations, rocks, hills, and valleys of great extent, or ravines more or less confined. (See plate A.)

Of this almost universal formation, GRANITE, the substance called Crystal or Quartz, forms a principal part, and may be known from its associates, *Felspar*, and *Mica*, by observing the following characters.

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* Imagine a valley of any extent, betwixt two lofty points of Granite, to have been subject to repeated influx and inundations, which have brought together, as into a reservoir, both animal and vegetable remains, and the decomposed particles of its confines; such a tract would constitute what is termed the filling up or flat (*Floetz*) formation.

Some varieties of *Granite* are very small grained, consequently the component parts are more difficult to be distinguished than in others, therefore, I recommend to the beginner, first to examine specimens of the large-grained, in which the three substances may be more distinctly seen, and to notice with attention each constituent part separately.

QUARTZ.

HOW QUARTZ MAY BE KNOWN IN GRANITE.

QUARTZ (Silex*), the immediate subject of our inquiry, has generally a shining lustre, is of a light color, and not unlike glass; the fracture is uneven,

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* Silex consists of Silica and Oxygen, the latter in the greater proportion; Berzelius states it at 54 per cent. It forms also 84 per cent. of water, and 23 of air. Oxygen may be understood by the learner as the cause of iron rusting; for the oxygen of the atmosphere combining with the iron forms a brown powder *(rust)*, which is an Oxide of Iron.

Iron entering into the composition of earthy substances, attracts Oxygen from the atmosphere, and gives to them brown and red brown colors.

Oxygen is the mineralizer of many metallic ores, particularly Tin, and is the occasion of its great weight.

irregular, not of any determinate form; it is sometimes imbedded in Felspar, and, when broken across, resembles Hebrew characters. It is commonly inclining to opaque, white, and not unfrequently smoky, grey, or brown, of different shades; these are its usual appearances, though it occurs yellow, pale or deep pink, and approaching to red; also violet blue. It is hard to the knife, but a good file will make an impression; it easily scratches glass.

Quartz appears massive, also in regular and irregular forms, compressed or aggregated. If diaphanous and very fine, it is then called Crystal, or *Rock Crystal*, some varieties of which are of various colors, as has been before stated.

Silex is also in great abundance in other Rock formations besides Granite; it occurs in extensive veins, and patches of great magnitude, skirting or covering rocks, and there are few metals that it is not associated with.

Silex is so universally diffused, that it would be difficult to say where it is not. Flint, Chalcedony, Agates, Jaspers, Breccia, Petrified Wood, Hornstone, Felspar, Clays, Mica, &c. &c. &c. partake largely of this substance; and the very numerous and extensive class called Sandstones, coarse and fine, and of almost every denomination, are composed of it, whether reduced to pebbles or gravel, to large or small-grained sand, or to the finest particles called dust; in which state it enters succulent vegetables, and coats the stems of corn in the early stage of their growth, adding strength to them, and being conducive to their perfection.

FELSPAR*.

HOW FELSPAR MAY BE KNOWN IN GRANITE.

THIS constituent of Granite is generally in greater proportion than the others; it is not so hard as Quartz†.

When a piece of Granite is broken, the crystals of Felspar will generally appear as if split or divided, with a smooth flat fracture, and a regular form, or a tendency towards it, which is not the case with Quartz.

Felspar is commonly of a light grey color, and has a shining, pearly, and silk-like lustre; it is often pale or deep red, and then forms red Granite. It is sometimes transparent, also blue and green. Labrador, or irridescent Felspar, is very beautiful; it is massive, and exhibits the finest variety of colors in the same specimen.

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* *Felspar* contains a portion of Potass, which hastens it to decomposition, when it forms Clay; this alkali meeting with Iron in the state of Oxide or Sulphuret, produces various changes in the appearances of Granite.

This substance, properly speaking, belongs to the Argillaceous Class; but as it is a constituent of Granite, I have thought it best to describe it here, as well as Mica, which belongs to the Magnesian Order.

† Granite sometimes contains a large portion of Hornblende (see Magnesian Order), which, in some cases, resembles Mica. Tourmaline and Schorl are often imbedded in it, also Precious Stones, as Aquamarine, Topaz, Garnet, &c.

Felspar occurs in distinct crystals; but it is generally aggregated, confusedly crystallized with Quartz and Mica; also sometimes disintegrated. It is often in decomposition, when it becomes dull, earthy, and passes into Clay. If these characters are well noticed, Felspar will easily be distinguished.

MICA.

EASILY DISTINGUISHED IN GRANITE.

MICA, the remaining constituent of Granite, is generally of a yellowish color, and has a strong metallic lustre; it occurs in hexagonal tables, composed of delicate foliæ, as thin as fine paper, and extremely elastic. In mass it has frequently a smoky, brownish tinge, but in fine laminæ it is commonly transparent, and used to cover objects for the microscope; it is employed in Russia for windows, hence called Muscovy glass. It is often seen in soil, and at the bottoms of rivulets, in South America, and many travellers have brought it home, believing it to be gold! Mica is soft, easily scratched by the knife, and produces a white flaky powder. It contains a portion of Iron, Potass, and Manganese, all of which tend to hasten it to decomposition.

ARGILLACEOUS ORDER

CONTAINS A LARGE PORTION OF SILEX,

AND is considered next in abundance; it commonly appears in the form of Clay, and is more or less indurated.

Primitive Schistos, or *Clay Slate*, belongs to this order, which often presents itself, alternating with Granite. In it are veins filled with Quartz, Fluor, &c. and various metallic substances. Clay Slate is of a dull dark color, bluish black; lamellous; splits freely, absorbs moisture, and has an earthy smell; it is soft when scraped, and cannot be mistaken after being once examined.

Primitive Porphyry is very hard and compact; color red brown, with angular spots of a faint yellow. It occurs also dark green, with light colored patches. The variety called Egyptian Porphyry is the most valued.

Green Stones, from containing a great portion of Felspar, belong to this order; and though they are so intermixed with Hornblende, which is frequently in minute particles, yet the Felspar may be known by its lustre and flaky appearance. It is very difficult to determine the relative position of many varieties from specimens.

Basalt, Trap, Grau-wacke, Toad stone, and *Shale,* contain large portions of Argil and Silex.

These substances, when decomposed, (to which many varieties are subject), form Clay. The Felspars produce the finest, which is used to make China and the best earthenware. Clay-slate, Shale, and the coarse varieties, when decomposed, are used by potters, and for making bricks. The beginner may discriminate common Argillaceous substances, merely by wetting them, when they become tenacious; or by breathing on them, when they give out an earthy odor.

LIMESTONE,

COMBINED WITH CARBONIC ACID.

PRIMITIVE LIMESTONE occurs in beds, or filling fissures in the Granite formation. It is granular and crystallized, also compact, as that from the Isle of Tiree. It does not contain any animal remains or vegetable impressions; it is not common amongst the Primitive Rocks, neither is it abundant in the Transition formation; when it occurs in the latter it sometimes contains traces of organic remains.

In the Secondary, or what is termed the flat formation, Limestone is very generally distributed, forming

mountains comparatively of less magnitude than the primitive, valleys and plains; it exhibits regular marks of stratification, shewing evident signs of an aqueous deposit at different and distant periods, appearing in great part to be formed of marine remains.

These mountains, though of small extent, present lofty and rugged features, as if separated from each other by some violent concussion, which has rent them asunder, and in many situations thrown the surface into great confusion. In this formation are situated fissures and veins of great depth and magnitude, which are filled with metallic substances, generally Lead Ore, and accompanied with Zinc, Barytes, and Calcareous Spar. There are instances of veins being worked in this Limestone from two to four or five miles miles in a direct line, producing an immense quantity of lead.

Those Limestones which take a good polish are called Marble, they consist of innumerable varieties, according to the impression of the marine exuviæ of which they are composed.

The Black Marble is most esteemed, and the best is in Derbyshire, near Ashford, where mills are erected for working it; also at Derby; both of which are in the possession of Mr. Brown of the latter place.

Chalk belongs to this order; it pervades a considerable extent of country, and is too well known to need any description. It contains great quantities of shells in a petrified state, as echinites, encrinites, madreporites, &c. also vegetable impressions.

Gypsum — Alabaster, is Lime combined with sulphuric

acid*. It is very abundant in Derbyshire and Nottinghamshire, and forms a considerable extent of country, filling cavities in the Red Marl, and rising into low hills. It is soft, and may be scratched by the nail, which sufficiently distinguishes it from Marble. It is in great use, and when burnt, it forms plaster of Paris, and is used in forming busts, mouldings, and flooring.

Selenite, a crystallized and transparent variety, is sometimes found detached; it contains a larger portion of water than Gypsum.

After the preceding Earths, so generally distributed, the *Magnesian* claims our attention; it does not occur, by any means, in so great a proportion as the others; on the contrary, it may be deemed scarce, though it enters into combination with some Limestones.

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* Lime, combined with Fluoric Acid, forms the beautiful fossil called Fluor; that variety from which such elegant and beautiful vases are made in Derby, is peculiar to one mine. Fluor has generally a cubic form. Fluoric Acid attacks and corrodes glass, which no other acid acts upon.

MAGNESIAN ORDER.

MAGNESIA IS ALWAYS COMBINED WITH OTHER EARTHS.

THE substance called Serpentine belongs to this order; it occurs at the Lizard, in Cornwall, in a tract of several miles extent: another variety is found in Scotland; it is also met with in other countries, particularly in Labrador. Many of the Traps and Amygdaloids contain portions of Magnesian earth, which may be known by their being slippery or greasy to the touch; Mica, Talc, Asbestos, and the soap-like substance, Steatite, contain large portions of it.

Hornblende, a substance very generally diffused, is a constituent of Gneiss and Sienite, and is sometimes found in Granite, also in Serpentine; it may be known from Mica on being scraped with a knife, when a dull green powder will be produced. It is also very abundantly disseminated in Basalt, Trap, Amygdaloids, and Green Stones; it is ferruginous, and, when in decomposition, frequently gives the red color to Clay.

SULPHATE OF BARYTES,

BARYTES COMBINED WITH SULPHURIC ACID.

BARYTIC Minerals form so small a portion of the Earth's surface, that they rather belong to the class of fossils; and though by no means scarce in this country, yet they are so limited, as not to admit of the most distant comparison with any of the preceding; they are commonly found in veins, and may be known by their great weight. They yield to the knife, and are frequently massive, and of an earthy texture, resembling Chalk, also crystallized and transparent. Barytes is an alkaline earth, becomes caustic on being exposed to a strong heat, and ultimately melts.

CARBONATE OF BARYTES,

CARBONIC ACID AND BARYTES.

A VARIETY called *Carbonate of Barytes*, is more rare; it has generally a striated and diverging fracture; is very compact, and, as Common Barytes, may be known by its great weight; it effervesces with diluted acids.

SULPHATE OF STRONTIAN.

STRONTIAN COMBINED WITH SULPHUR.

STONTIAN is an Earth newly discovered; and resembles Barytes in some particulars, but it is not so heavy, and is generally of a sparry texture; often of a very light blue color, and is then called *Celestine*; it occurs granular, fibrous, and earthy.

CARBONATE OF STRONTIAN.

STRONTIAN COMBINED WITH CARBONIC ACID.

ANOTHER variety, called *Carbonate of Strontian*, is green and brown, striated; it is generally accompanied by Earthy Barytes, and is very rare.

Strontian may be known by mixing a little of it in the state of powder, with Spirits of Wine, which when set on fire produces a beautiful purple flame.

The *Sulphate of Barytes* is most abundant in Derbyshire, and Limestone countries of that formation, it occurs also in Sandstone and Shale; where it is found earthy

and crystallized, in great quantities, considering it to be a veinous production.

The *Carbonate* is less abundant, and although it is produced but in small quantities in three or four mines, it is plentiful near Chorley in Lancashire. It has lately been found in Shropshire.

Sulphate of Strontian, in small quantities, is not uncommon; but the great repository for it is near and about Bristol.

The *Carbonate of Strontian* is extremely scarce, and exists only at Strontian in Argyleshire; although small portions are said to have been discovered at Lead Hills in Dumfriesshire,

LESSON VI.

DESCRIPTION OF ROCKS,

WHICH COMPOSE WHAT IS TERMED THE PRIMITIVE FORMATION.

AFTER having described the Earths as they commonly occur, it will be proper to explain what is meant by the word formation,* when applied to Earthy Substances.

Geologists agree that there are certain Rocks more ancient than others, and have denominated those which are

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* The crust of the earth is supposed to have been formed at different and distant periods; hence each period is called a Formation, as the Primitive, Secondary or Transition, Floetz or flat, and Alluvial.

Geological Collections may be obtained at a cheap rate, with the name and description of each specimen, explaining to what

Primitive Rocks.

Primitive Rocks & Secondary.

Stratified Rocks, Floetz Formations and alluvial deposit.

J. Mawe, 149, Strand.

considered the oldest, *Primitive Rocks.* Thus, those of Granite, &c. are said to be of the Primitive Formation, whilst others are considered of the Secondary or Transition, and a third class are styled the Floetz or Flat Formation, being formed upon the Primitive or Secondary, and bounded by rocks of that description.

It is not my intention to point out where these Rocks are to be found, except in particular cases, nor do I think it necessary to enumerate *all* their varieties, but to explain to the beginner the characters by which they may be known, after having examined a few specimens, without entering into a particular account of the substances which compose them; therefore, as Granite is considered of the first or oldest formation, I shall commence a general and brief description of some of its varieties.

Although the Crystals of *Quartz*, *Felspar* and *Mica*, are generally in this substance so confusedly aggregated and intermixed with each other, yet they often occur distinct, particularly on the surface of pieces wrenched from hollows or cavities; therefore, in order that the learner may have a correct idea of these substances, I will place them separately.

Quartz. Crystallized, or in fragments.

Formation it belongs, by which the learner will be enabled to determine the substances he may generally meet with. These collections, on a small scale, will be interesting to those who read books upon Geological subjects, and may be purchased at from Two to Ten Guineas. The time necessary for selecting, arranging, and describing, forms a considerable part of their cost.

Felspar. Crystallized; shewing its foliated, also its uneven fracture.

Mica. Foliated and crystallized; soft, and easily scratched.

Granite, composed of large crystals of Quartz, Felspar, and Mica, distinctly or confusedly aggregated, as the Grey Granite on Dartmoor.

Granite, common variety, neither large nor small grained, being composed of Quartz, Felspar, and Mica, in regular proportions.

Granite, small grained, color generally grey; often occurs with Garnets imbedded in it.

Granite, composed of bronze colored, or dark, smoky Mica, sometimes almost black, the Mica predominating.

Granite, GRAPHIC, is composed of long crystals of Quartz, imbedded in Felspar, and when broken across, exhibits Hebrew-like characters, hence called *Literatus.* In this variety the Felspar and Quartz shew their characters very distinctly, and the Mica occurs in thick patches.

Red Granite, so called when the Felspar predominates and is of a red color, it is common in Scotland; the Cathedral, on the Isle of Icolmkil, is built of it.

Granite, the Felspar of which is disseminated and de-

composing, or quite soft, forming Clay; the Mica and Quartz appearing unaltered*.

Granite, composed of Felspar and Quartz, approaching granular, with Schorl distributed, and a small portion of Mica, also contains large and perfectly defined Crystals of Felspar imbedded. This variety is called Moor-stone in Cornwall, and some have named it Porphyritic Granite; it may be seen in the pavements of London, particularly after rain, the crystals of Felspar protruding above the surface. This variety differs much in the proportions of its constituents; it frequently contains Hornblende, and the finer part of this Granite resembles SIENITE. Garnets, Tourmaline, and Schorl, are often imbedded in it.

White Stone is fine-grained, consisting chiefly of granular Felspar, with particles of Schorl, and sometimes Garnets, it often appears as if in decomposition; it is associated with Quartz and Mica, and is probably a variety attendant on Granite.

Gneiss, is composed of Quartz, Felspar, and Mica, the latter lying parallel and forming thin beds; it has been called slaty or stratified Granite, which it really is.

Another variety is, by some Geologists, called *Gneiss*, when Hornblende forms a constituent, without its being stratified.

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* Felspar contains more or less alkaline matter, which subjects it to decomposition, as has been before stated.

Sienite is composed of crystals of Felspar and Hornblende, confusedly aggregated; it is commonly very hard and of a dull red color, as that at Mount Sorrel, in Leicestershire; it occurs also grey and dark green. Sienite is not very abundant, and is often taken for Granite. The grand head of Memnon, in the British Museum, and the colossal figures in Egypt, are of *Sienite.*

Sienite, when composed of more Hornblende than Felspar, is often called Green Stone, of which there are many varieties, indeed the term Green Stone depends much on the color.

Topaz Rock, in appearance, resembles Gneiss, but consists of granular Quartz, Schorl in spicula, Topaz, and Lithomarge (Clay) in layers. Topaz and Quartz are commonly crystallized on some part or other; it is generally of a grey color.

Mica Slate is Mica and Quartz laminated, or Mica disseminated in small crystallized particles, having a slaty texture; it is abundant, and has frequently Garnets, Schorl, and Precious Stones imbedded in it. Mica Slate has often an undulating and curved structure; in some cases it appears almost wholly composed of Mica. This variety consists of very fine particles, which pass into Clay Slate. The Topaz mines in Brazil are situated in this substance.

Quartz Rock is both massive and granular; it frequently contains Mica, and sometimes Talc, a substance resembling Mica; also often large portions of Tourmaline

and Schorl; it is then called Schorl Rock. Topaz, Garnets, Fluor, and Pyrites, are sometimes imbedded in it.

The following, called Primitive Rocks, probably were not formed at the precise epoch of the preceding.

Clay Slate is next in abundance to Granite, and often alternates with rocks of that order, forming mountains, filling hollows, &c. It is called Killas in Cornwall, and in it many metallic veins occur, particularly those of Tin and Copper, also Lead; the latter is commonly rich in Silver. Clay Slate is generally of a dark color and earthy; it is also slaty and shining, sometimes appearing as if composed in great part of fine particles of Mica; these varieties soon decompose. Slate used for roofing and paving, belongs to this order; in it crystallized Pyrites and Rock Crystal, finely defined, are frequently imbedded.

Flinty Slate, is of a black color, hard and compact, texture very fine; appears an intimate combination of Hornblende and Silex; it contains numerous capillary Quartz veins. Lydian Stone is a fine grained variety; it occurs in beds, with Porphyry and Grau-wacke, and in rounded masses in the alluvium.

Porphyry. What is commonly understood to be Porphyry, is a hard, red-brown substance, enveloping or containing crystals imbedded in it, which are generally Felspar of a light color; this variety is called Red Egyptian

Porphyry. Green Porphyry is of a dull dark green, with crystals of Felspar of a light green; the ancients called it Oophites, but the modern Italians, *Serpentino*. Brown Porphyry, as that from Sweden, resembles the Egyptian, but is not so hard.

Jaspers of various colors and descriptions are sometimes in fissures, filling cavities in this formation, and constitute veins.

Jaspers are commonly very hard, fine texture; generally of a red or dull green color, often striped, and contain a large portion of Iron.

*Serpentine** is not very abundant in this country, and when associated with Primitive Rocks, it is considered of that formation. Serpentine is composed of a large portion of Hornblende, and commonly dark colored, as brown-red with reddish marks, or dull green, variegated; it occurs also lighter or darker, often spotted, sometimes with splendent shining Hornblende. Some varieties appear more compact than others: and after examining a few specimens, it may generally be known by its different colors, and being rather greasy to the touch; when breathed upon, it gives an earthy odor; it is soft, easily scraped.

Native Copper has been found in this substance in delicate ramifications and leaf-like.

This stratum contains veins of Talc and Steatite, both compact and earthy; also Asbestos and Magnetic Iron Ore.

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* *Serpentine.* This class is of various colors, sometimes resembling the skin of Serpents; hence its name.

Primitive Trap. This substance is of a dark color, approaching black, and composed almost wholly of minute crystals of Hornblende. It is hard and difficult to break, and has sometimes an homogeneous appearance; in some cases probably it migrates into Chlorite slate. There are other varieties that are granular, compact, and slaty, which have been confounded with Basalt. In decomposition they appear highly ferruginous, and with numerous vesicles.

Green Stones, composed of Felspar and Hornblende, belong to this formation when associated with Primitive Rocks, and may be distinguished from those of the Secondary Formation, by their constituents being always crystallized and harder; they differ from Sienite principally in color, and are considered to contain a greater proportion of Hornblende.

Primitive Limestone, when crystallized, appears coarse and granular, as Dolomite and Statuary Marble; it is also found compact, as the Limestone from Tiree, where it occurs of a beautiful flesh-red color, enveloping Sahlite and Titanium; it effervesces with acid, and easily yields to the knife. Another variety from Scotland, is clouded, dull green; it is of close texture, granular, and receives a high polish.

Primitive Gypsum is so named from associating with Primitive Rocks; though harder than the other varieties, it yields to the nail, and is both granular and compact. The Italian Alabaster is said to be Primitive; it occurs filling cavities, and forming hills of small extent.

Many new substances have lately been discovered in this formation, but their application at present is confined—probably future experiments may develop their use.

OBSERVATIONS.

THE surface of Primitive Rocks may be supposed to have been much altered since they were formed; split, separated, and scattered in all directions: whether this has taken place from desiccation or other causes, we know not, but they appear without any regular order, presenting rude, barren, perpendicular, and overhanging projections, with pointed elevations. Such mountains may be supposed to be represented in plate A, which is intended merely to give the learner an idea of the rugged Alpine scenery. Thus a valley may be filled by a deposit of Blue Clay, Sand, &c. as *(a)*.

The greater part of the Globe being still covered by Sea, considerable alterations and changes must be constantly taking place, from the inhabitants of the deep forming their coral abodes, and the effects of currents sweeping oceans of other substances amongst them, producing rocks of great magnitude and vast extent.

This short account of what are termed Primitive Rocks will enable the learner to determine and distinguish them from those of the other formations; but it is necessary to observe, that hollows, rents, or fissures, may be filled, not

only with metallic ores, but with varieties of their own rock species, as Granite, Sienite, Porphyry, Jaspers, Hornstones, Green Stones, Calcareous Spar, &c. &c.

Clay belongs to every formation, being the natural result of the argillaceous substances when decomposed.

Granitic and Clay Slate are the predominant rocks in Cornwall and Devonshire. The Malvern Hills are a Granitic formation; also those in Charnwood Forest; it then makes its appearance again in Westmorland and Cumberland, and is predominant in Scotland.

The high mountains in Scotland—the *Alps*—the Ridge in *Brazil*—the *Cordilleras*—and the *Himalayan* chain in Asia, are of Granitic formation.

LESSON VII.

SECONDARY FORMATION.

SEE B. PLATE A.

THE Globe being formed, and Land and Water separated, the natural result of Time would evidently produce great changes; thus the disintegration and decomposition of the Primitive Rocks, arising from the action of the atmosphere, and other causes of which we have but little idea, together with various deposits, must naturally produce another class of earthy substances, Rocks. This class is called the Secondary, and is supposed to have been coeval with vegetable and animal creation, as few traces of either have hitherto been discovered in this formation. It is a received opinion that at this epoch creation was confined to marine animals, of which remains have been observed in some of the rocks of this formation.

The rock that presents the principal feature in this Class is called grau-wacke, a mechanical deposit; the others are Transition Trap, which may be both chemi-

cal and mechanical, Transition Limestone, and Flinty Slate; these are the limits of the transition formation according to the present system, although, no doubt, there are many other rocks accidentally dispersed amongst them, and generally composed of particles precipitated both mechanically and chemically. The most important of this series is considered a mechanical mixture or deposit, and may be compared to a mud bank in a river; but when it appears more or less crystallized, it is supposed that these crystals have been formed by a chemical combination of their component parts, influenced by attraction and affinity, which is necessary to constitute a chemical deposit.

Grau-wacke is considered the first mechanical deposit*; that is, an aggregate cemented by Ferruginous Clay, and composed of the debris of the primitive Rocks, whether coarse or fine, compact or slaty, granular, rounded, &c. in great variety.

Grau-wacke must, therefore, be extremely different in its appearance and texture, often resembling coarse Sand-stone; and from its nature, its constituent parts must be very various. Its color is generally dark, dull, and often greyish; its base is argillaceous; it has sometimes, when composed of fine particles, a slaty texture, and homogeneous appearance; it is of great extent and highly metalliferous, *i. e.* contains metallic veins. Some varieties are much harder than others.

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* A substance entirely formed by the disintegration of others is called a Mechanical deposit.

An examinatiou of some well defined specimens of this substance would enable the learner to form a better idea of it than description can possibly do, its appearances being so various.

Grau-wacke Slate is in greater abundance and of finer texture; has evident marks of stratification; it has a more homogeneous appearance; in this formation hollows are sometimes filled with Limestone, which contains marks of the remains of marine substances.

Secondary Limestone is generally considered that which is associated with other Rocks of the same formation, connected with those of the Primitive; this Limestone is a deposit more mechanical than chemical, and scarcely can be called granular; its texture is fine, and its colors very variable, and frequently strongly contrasted, as red, black, white, yellow, &c.; it is abundant in Devonshire, both at Torbay and Plymouth, where it exhibits marks of stratification; some varieties, when cut into slabs and polished, are very beautiful; the streets of the town of Dock*, at Plymouth, are paved with it. In the north of Devonshire, near Castle Hill, this variety of Limestone occurs, filling large cavities in Grau-wacke slate. In it are many Sparry white veins, and abundance of Pyrites. Fossil petrifactions occur, but not of the same description, nor in any degree so abundant, as in the Limestone of the Flat or more recent formation.

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* The town of Dock belongs to Sir John St. Aubyn, a most liberal patron of the arts. The pavement of Fore-street is formed of beautiful slabs of this marble, and is considered to be the finest in Europe.

Transition Trap is composed of Hornblende, furruginous Clay, Felspar, and granular substances, and is in part both a mechanical and chemical deposit. Varieties appear more or less crystallized; they are hard, contain a large portion of Iron, and alter their appearance in every stage of decomposition.

Numerous Green Stones belong to this order; they are composed chiefly of Hornblende and Felspar, confusedly intermingled sometimes partially crystallized. They are generally of a dull green color, and often approaching brown black; they are frequently traversed by small veins of Quartz.

Wacke. Being cellular and resembling burnt Clay, it has often been supposed to be of volcanic origin, without considering that such vesicles may have been formed by air or water, or by the decomposition of some alkaline substance.

Amygdaloid is another variety, containing almond-shaped nodules of Chalcedony, Zeolite, Green Earth, Agate, Jasper, &c. and is often vesicular. It occurs hard, soft, and sometimes earthy, as it may be less or more decomposed; further description will avail the learner but little; specimens must be examined before he can become well acquainted with the substance.

Trap is the Swedish term for ladder; Green Stone Rocks, Basaltic Rocks, and Hornblende Rocks, often appear one above another, forming steps, hence the term Trap, ladder. It is particularly visible at Staffa, and in various parts of Scotland, and other places. Rocks of this

class decompose into ferruginous Clay, the exterior of which is frequently soft, and the interior unaltered.

Transition Flinty Slate, is a siliceous substance; which occurs in thin beds with Grau-wacke and secondary Limestone; it is compact, and marked by alternate lines, stratified, of a dark or lighter color.

Of this, the Secondary Formation, Grau-wacke is said to be the only one that is Metalliferous; in it are situated many strong and large veins of Lead Ore, both in Scotland and the north of England. The grau-wacke formation is no doubt more extensive than has hitherto been suspected, and substances now known by other terms, will probably come under this denomination.

The engraving B, plate A, is intended to shew Primitive Rocks, blunted by decomposition, and the Transition Rocks, forming from their disintegration, upon their bases, skirting them.

It is highly probable that this formation is of greater extent, also that more varieties will be ranked in this class: when our ideas become unfettered, reason will have larger scope for fair play, and no doubt discoveries will be made, and different arrangements take place, as the formation of Transition Rocks appears to be involved in great obscurity; nor is the following free from objection.

FLOETZ, OR FLAT FORMATION*.

C. PLATE A.

THIS formation is supposed to be more recent than either of the preceding, and to have been formed by deposit *(chiefly mechanical)* from the disintegration of the others, and the debris of organic remains, upon the Primitive or Secondary, having evidently been formed at various epochs, and by various operations, filling or rendering more flat extensive valleys between elevated Rocks of the Primitive class. This order is very general throughout a great part of the globe, and shews evident signs that it has been chiefly deposited and formed under water, after which various alterations must have taken place, as the visible confusion and irregularity of the strata plainly indicate.

It is my desire to endeavour to explain the substances which compose this class, so that they may be known from others, and to state the general received opinion relative to their formation and origin.

The plate C is intended to exhibit the appearance of stratified Rocks, as Limestone *a*, *b*, *c*, also a section of a perpendicular vein of Lead Ore, *v*; and a flat or pipe vein, *p*.

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* The learner must not expect to find this arrangement or description to correspond perfectly with any peculiar place, as the different rocks which are comprehended in it may be very distant from each other.

The letters, *f, f,* shew the separation of the rocks, and irregularities of the surface in this Limestone; patches of Trap or Toadstone occur imbedded, independent of the regular series of that formation. This stratum is considerably below the Coal.

The beds of Coal are represented by *d, d;* they are independent of each other, having earthy deposits, as indurated Clay and Sandstone, between them; *g* is meant to shew the direction of the Whinstone dyke passing through the Coal beds, which it breaks and throws into great confusion: *i* represents Sandstone lying above a bed of Schistos.

The Coal formation is attended by compressed stems of plants, reeds, ferns, and numerous other vegetable impressions, frequently carbonized and imbedded in Micaceous grit, Shale, and Clay Ironstone, also fresh water shells.

The Old Red Sandstone is represented at the bottom of the plate, and marked R S; next in succession, above it, following the Wernerean arrangement, is the first Floetz Limestone, FL; on which rests the Oolite, marked O; then the stratum of Shell Limestone, marked S L; upon which lies the Magnesian, marked M.

The undulating hills may be supposed to be the chalk formation; and the hollows *e e,* basins filled with Clay or Gravel; *h* represents a lake, where a fresh water formation is going on, which, when filled with earthy deposit, will constitute what is termed a *Clay basin.*

Old Red Sandstone—First Sandstone rests upon some of the preceding, and is chiefly formed from their decomposition, particularly Grau-wacke, with some varieties of

which it is closely connected, frequently having more the appearance of decomposed Ferruginous Clay than Sandstone. It is commonly red colored, often hard, and composed of large pebbles; it is considered of great extent, particularly in Devonshire and Wales, and interposes between the Secondary Formation, (upon which it rests), and the Floetz Limestone. It is not considered metalliferous, nor does it even often contain fossils. As the Transition Rocks are, from their nature, more subject to decompose than the Primitive, this Sandstone may be allowed to be generally formed from them.

First Floetz Limestone—Metalliferous and Mountain Limestone. It is supposed to lie immediately above the preceding, and to be chiefly formed of marine exuviæ; it is of great thickness (probably never cut through, although numerous mines are worked in it); it is regularly stratified, and in parts almost entirely composed of fossil shells: it is moderately hard and compact, rarely granular or crystallized. It forms lofty mountains and deep ravines, exhibiting evident signs of having been disturbed by some cause, that has thrown the surface into great confusion, by which numerous Metallic veins are exposed.

In this stratum marble of great beauty is found; some of the beds are composed of Corals, Astrolite, and Madreporite, which, when cut, have a stellated appearance. Others exhibit almost an entire mass of Marine Fossils, chiefly the Entrochite, Belemnite, and Gryphite. These Limestones, when strongly rubbed with a harder substance, generally emit an unpleasant smell.

There are, doubtless, many formations of Limestone partially distributed, to which it is impossible to attach systematic regularity of situation.

First Floetz Gypsum, Werner considers extensively distributed, and places its situation upon the preceding Limestone: it is soft, granular, and compact; sometimes contains crystals of Quartz, Boracite, and Andalusite. It is met with in various parts of Europe, associated with Rock Salt, and Clay.

Second or Variegated Sandstone, is a deposit of fine granular Sand, often striped red, brown, and yellow; it is of considerable thickness and extent, contains a portion of Clay, with Oxide of Iron and Mica; it consists of beds more or less thick, is widely dispersed, and used for various architectural purposes.

Second Gypsum. This consists of the compact and fibrous varieties, with Selenite; it is of considerable extent, filling cavities and forming hills, accompanied by Red Marl and resting upon Sandstone; it is in abundance in Derbyshire and Nottinghamshire, particularly near the river Trent; no metallic substances nor fossil remains have been hitherto observed in it in this country.

Oolite—Shell Limestone, as its name imports, is chiefly composed of shells, and is considered of more recent formation than the preceding; it is soft, loosely cohesive, generally of a light brown color, and has sometimes a shining and foliated fracture. It frequently constitutes and abuts in irregular mountains. In this formation there are many basins of Sand, Gravel, Blue Clay, &c. (probably arising from the desiccation of lakes) filling up ravines and bounded by Limestone hills. Mineral waters, saline, magnesian, and chalybeate, are sometimes discovered in these deposits, at various depths

from the surface. The Oolite formation is chiefly composed of spheroidal particles, and contains numerous petrified shells and marine remains.

It is rarely metalliferous; the range of mountains in Dorsetshire, Somersetshire, and Gloucestershire, are of this formation. It is much used for building, and so soft as to be cut with a saw.

Rock Salt is clear and transparent, or colored red and brown, rarely blue; it is situated in basins of gritstone, though it is considered to belong to the Gypsum formation; it is surrounded in this country by Sandstone, indurated Clay, and Marl, always attended by Gypsum and sometimes thin beds of Limestone.

Chalk. This formation (supposed to be one of the latest of the Limestone class) occupies considerable space in this country, and rests upon Sandstone. It is too well known to need any description; in it are regular beds and nodules of Flint. This singular variety of Limestone contains numerous fossil remains, particularly Echinite, Pinite, Dentalite, &c. &c.; it alternates with Sandstone, which often appears both above and below it.

In the valleys of the Chalk formation are large deposits of Sand and Clay, some of which are several miles in extent; London is built in one of these, hence called the London Clay basin. In these Clay deposits are a variety of fossil shells, &c.

LESSON VIII.

COAL FORMATION.

OF this substance, and its usual attendants, something has been said before.

The high importance of coal to mankind, and its peculiar application to our manufactures, as well as our necessities and comforts, render it indispensable in this country, and I may fairly ask, what could we do without it, or substitute for it?

Coal is met with in various parts of the Globe, and though thin veins and patches may have occurred in Granite, Limestone, &c. it is considered to belong to the Magnesian, Lime, and Floetz Sandstone formations, and lies in strata, alternating with it,

Compact Coal. Canal coal, often exhibits a wood-like structure.

Foliated Coal, is shining, and often stratified with fibrous charcoal.

Slaty Coal has a dull and earthy appearance.

Irridescent Coal. A variety of *foliated,* and often exhibits beautiful colors, hence called Peacock Coal. It is also sometimes covered, as if plated, with shining Pyrites.

Bovey Coal, Ligneous Coal, and *Peat.* These varieties belong to the Alluvial deposit, and are met with a little below the surface.

Bovey Coal has a very perfect, wood-like texture, and is of a brown color, rarely carbonized.

Peat is sometimes partly carbonized. It is composed of vegetable fibres, and in some situations fills hollows, denominated peat bogs, morasses, &c. It appears to be passing into Coal, and probably only wants a covering of the Sandstone deposit, sufficiently thick to exclude it from the air, to complete the process.

QUERY. Suppose fermentation to take place, and heat produced under pressure, would not peat become carbonized, and form coal?

NEWEST FLOETZ TRAP FORMATION.

WERNER has applied the above title to this class of rocks. It consists of Basalt and its varieties, Wacke, Amygdaloid, Trap Tuff, &c.

Basalt is considered either homogeneous, or composed chiefly of black colored ferruginous Clay; it is of close texture and heavy.

Basalt also contains Iron Sand, and has frequently a Porphyritic structure, enveloping small, dark green patches of Olivine, which have a glass-like fracture; also a black substance, called Augite, granular and crystallized, together with Hornblende, and sometimes Quartz, Chal-

cedony, and Calcareous Earth. It is rather difficult for the learner to discriminate the Crystals of Augite from those of Hornblende, until they have been properly explained.

Basalt has frequently a columnar structure, and its exterior is commonly porous (arising from the decomposition of some of the substances), which in various cases gives it a cellular appearance, not unlike lava.

Basalt is frequently Amygdaloidal, and contains Calcareous Spar, Green Earth, Clay, Zeolite, and Chalcedony; is often vesicular, and may, in many cases, be considered to decompose into the following.

Wacke. Has the appearance of a cellular, indurated Clay. The Augite, Olivine, &c. which were imbedded in Basalt, probably become decomposed into Amygdaloid, which, forming vesicles, finally passes into Wacke and Clay.

Grey stone, Porphyry Slate, and *Clink Stone,* may be considered to be varieties of either Basalt or Green Stone.

Trap Tuff consists of fragments of the preceding rocks, cemented together by an earthy base, forming a coarse *breccia.*

Green Stone occurs in this as well as the preceding formations, but it is considered less crystalline, and to be composed of finer particles, so as often to resemble a simple substance. Its color is usually dull green of various shades, sometimes reddish, and then called Sienitic Green Stone.

Amygdaloid. This rock has always a Clay base, and exhibits various appearances in different stages of decomposition. It associates with Basalt, and perhaps passes from it into Amygdaloid: it contains vesicles filled with Calc Spar, Green Earth, Lithomarge, Zeolite, Chalcedony, black spots of Hornblende, also Quartz and Agate; it has often a vesicular structure, and has frequently been taken for a Volcanic substance.

VOLCANIC.

ROCKS of Volcanic origin are supposed to be of modern formation, at least we know of many that are so. Volcanoes are not confined to the land only, for we have instances of islands rising out of the sea and sinking again! It is stated that there are upwards of two hundred active Volcanoes, many of which, at intervals, discharge lava and ashes in immense quantities; the heat is frequently so great (more especially during an eruption) that it acts upon the neighbouring rocks, giving them the appearance of volcanic origin. From Etna alone have been ejected ashes, lava, &c. which have covered towns, filled valleys, and totally changed the face of the country.

Sulphur, so generally combined with Minerals, occurs in immense quantities in and about Volcanoes; it is too well known to need any description. Numerous Salts, as Ammonia, Soda, Nitre, &c. are also found sublimed in the craters of Volcanoes.

Volcanoes in South America and Kamschatka do not appear of less importance.

There have been also many volcanoes which are now extinct, but have left sufficient marks of their existence. These have no doubt altered the face of nature in their vicinity; therefore it may be supposed that this formation is of much greater extent than has been imagined, and may be said to consist of numerous varieties, viz.:

Rocky Substances, altered by subterraneous heat, or ejected from volcanoes.

Lava. Compact or cellular; numerous varieties.

Obsidian, and Porphyritic Obsidian.

Vesicular Lava, Porous Lava, Pumice.

Volcanic Tuff. The debris of volcanic productions cemented together.

Volcanic Ashes.

Volcanic Sulphur.

Earthquakes that have shaken the globe, ingulfed whole districts, and raised mountains where plains existed, separated rocks, and thrown them into the greatest disorder, forming ravines and abrupt precipices, are most frequent in volcanic countries.

There are immense siliceous deposits from the hot waters of Iceland, resembling calcareous Tuffa, in some of which are patches which common observers would

take for flint, if the surrounding spongeous substance was detached. It may also be added, that the solvent power of hot water, when containing alkaline substances, is in a great degree unknown. Those who have examined the waters of Iceland are well aware of the siliceous precipitates, some parts of which much resemble Chalcedony, Hornstone, and Flint.

ALLUVIUM,

CONTAINING DIAMONDS, GOLD, PRECIOUS STONES, MICA, SANDY IRON ORE, &c.

THIS deposit has given great riches to the world, and is generally understood to consist of the loose earthy soil which covers the solid rock in every part of the globe, but more particularly the beds of rivers and water courses, whether left by floods or formed from the decomposition of the adjacent mountains; it has in general a gravel-like appearance, intermixed with pieces of rock of a larger size. These deposits are called Gold Mines in Brazil and Africa; they are often of great extent, formed by the low land bordering on a rivulet.

Calcareous Tuffa is in great abundance in Limestone countries, particularly at Matlock, in Derbyshire, where it forms hills on the banks of the Derwent; in it are found Land Shells, Deer-horns, Wood, &c. The spring waters in their course lose a part of the carbonic gas, and precipitate the earth held in solution, on moss and vege-

table fibres, until their course is frequently choaked.—Those springs are called petrifying-wells, because straw or sticks that are placed in them become incrusted.

Alluvial Soil is moved by high tides, currents, and inundations, often forming shoals at the entrance of rivers, and on various parts of the coast. Nay, heavy gusts of wind carry quantities away, appearing like a moving cloud, and changing the face of the country wherever it is deposited; nor is it uncommon for trees and herds of cattle to be covered by it.

Alluvial Soil—containing Diamonds—Brazil.

Alluvial Soil—containing Gold, Iron-sand, &c.—Africa.

Alluvial Soil—containing Rubies, Chrysoberyl, Hyacinth, Jargoon, &c.—Ceylon.

Alluvial Soil—containing Tin Ore, &c.—Cornwall.

This formation demands more notice; it is easily investigated, and is composed of the debris of the solid and moveable earthy contents of the Globe. Substances found in it have led to important discoveries.

After having concluded the foregoing pages on Geology, the student will be led to reflect on the division of the various and extensive order called rocks, whose characters are so obviously different from each other. Although it is difficult to fix their formation to any limited period, yet the structure of many of them conveys distinct

symptoms of their relative age, as may be clearly seen in a small collection of select specimens;—for instance,

Imagine the sea to leave a certain part, and rocks appearing, formed by the zoophytes which construct huge reefs of coral rock, resting upon, and covering those of a different quality, and of a prior existence.

Submarine volcanoes also may have been very active, and poured forth immense tracts.

The accumulations on the coasts—the filling of harbours and arms of the ocean—the retiring of waters—are evident to our senses; but the operations that are going on in the deep recesses of the earth, or below the unfathomable waters, are infinitely beyond our comprehension.

> " Works of the power supreme, who poured the flood
> " Round the whole earth, and called it good."

Then may we exclaim, can any mind be so vacant or insensible as not to notice the exact forms which minerals present? They are the geometry of nature, formed with mathematical exactness. Examine a piece of calcareous Spar, break it, and every fragment is a rhomb—see a cube of Fluor—a perfect hexagonal of Quartz—an octahedron of Diamond—of Iron—or of Lead Ore; or a dedecahedron of Garnet! then contemplate the laws by which these forms are produced in the mysterious laboratory of nature, directed by the infinite power of the Creator.

Werner has classed the Metals and Earths in the following order. The varieties belonging to each may be seen in any Elementary Work, or in the New Descriptive Catalogue.

CLASSIFICATION OF METALS.

Platina.	Tin.
Palladium.	Bismuth.
Iridium.	Tellurium.
Gold.	Antimony.
Mercury.	Molybdena.
Silver.	Nickel.
Copper.	Arsenic.
Iron.	Tungsten.
Manganese.	Tantalum.
Titanium.	Cerium.
Lead.	Cadmium.
Chrome.	Selenum.
Zinc.	Wodanum.

CLASSIFICATION OF EARTHY MINERALS.

These are arranged in what are called Families, and each is divided into Species and Sub-species, comprising great Variety.

Diamond.	Azurestone.
Zircon.	Felspar.
Ruby.	Clay Slate.
Schorl.	Mica.
Garnet.	Lithomarge.
Quartz.	Soapstone.
Pitchstone.	Talc.
Zeolite.	Hornblende.

Chrysolite.	Gypsum.
Basalt.	Boracite.
Dolomite.	Barytes
Limestone.	Strontian.
Apatite.	Hallite.
Fluor.	

SALINE MINERALS—EARTHY SALTS.

Alum.	Epsom Salts.

ALKALINE SALTS—SALTS OF SODA.

Natron.	Rock Salt.
Sulphate of Soda.	Borax.
Reussite.	Native Boracic Acid.

SALTS OF AMMONIA.

Muriate of Ammonia.	Sulphate of Ammonia.

METALLIC SALTS.

Sulphate of Iron.	Sulphate of Copper.
Sulphate of Zinc.	Sulphate of Cobalt.

INFLAMMABLES.

Sulphur.	Graphite.
Bitumen.	Resin.
Coal.	Retin-Asphalt.

Description

OF

COLORED PLATE.

SEE FRONTISPIECE.

A BRAZILIAN MINER WASHING THE ALLUVIAL SOIL FOR GOLD AND DIAMONDS.

THIS plate istaken from a view in Cerro do Frio, in Brazil. The situation is a ravine, through which a stream of water runs, called Mielho Verde; it is bounded by mountains of Granite, large blocks of which lie in all directions.

In the summer season a part of the bed of the rivulet becomes dry, and the course of the stream is sometimes changed by placing planks in such a manner, as to lay bare the other part, in order to remove the gravel or soil which has been deposited after heavy rains; for this purpose people are employed in digging, raking, and carrying it away to the nearest plain, where they throw it into a heap. It is generally observed that the soil nearest the solid rock is most abundant in grains of Gold and in Diamonds, consequently the surface of the rock is scraped clean. When the wet season commences, and the water is in sufficient abundance, the most skilful miners are employed in carefully washing this soil in small conical bowls. The operation is performed as follows: the

bowl being in part filled with water, about ten or twelve pounds of the Gravel are put into it, and continually stirred about until the rounded stones are clean: as the water becomes muddy, it is poured off, and fresh is continually added, until it is no longer turbid; then the larger stones are thrown away, and the smaller picked out with great care; below which the Diamonds will be found, and at the bottom the grains of Gold, generally accompanied with Iron Sand. The Diamonds are more easily distinguished when wet, having a peculiar lustre.

Gold and Platina, whether in larger or smaller grains, being so much heavier than Pebbles, or the earthy substances in which they have been imbedded, fall to the bottom of the bowl as soon as the earth is washed away from them.

The Plate represents a heap of gravel raked from the river, and a smuggler washing it by stealth, as, wherever Diamonds are found, the crown claims the property.—Men frequently go ten or twelve miles in the night, to obtain a sack of this Gravel, which they wash at home secretly. This is what is called hand-washing. There are other modes practised on a larger scale, which are more expeditious, but not so economical.

I have seen eight men procure upwards of twenty ounces of Gold in four hours, from a portion of soil not above two tons in weight, taken from a deep hole which occasioned an eddy in the river.

Description

OF

COLORED PLATE.

SEE FRONTISPIECE.

VIEW TAKEN AT CROMFORD HILL, NEAR MATLOCK.

THE grit-stone stratum is shown by the perpendicular rocks, upon which are a number of trees. Below is the Shale stratum, or Bituminous Schistos; upon which is placed a machine for drawing Lead Ore from the mine. This machine is commonly called a *Wim:* a part of the vein of Lead Ore is exposed, to shew its situation. The mine has been sunk through both the Grit Stone and Shale, and is at present deep in the Limestone. The *cupola*, or smelting house, has lately been removed.

Upon the right hand is represented a section of Limestone, A A, divided by Toadstone. This is introduced merely to show the substances which constitute the strata in this part of Derbyshire. Opposite to this lofty ridge of Grit, is a mountain of Limestone, which rises equally abrupt, forming a deep ravine, in which the village of Cromford is situated. From thence, proceeding to Bonsall, through a ravine formed by Limestone mountains, the Toadstone is first met with near a public house.

At the foot of Matlock High Tor, is the Second Toadstone, which forms the bed of the river: it appears on the

road side. About midway in the same mountain the Limestone is divided by the First Toadstone; and near its summit, a fissure is seen, from whence a great quantity of Lead Ore has been extracted: it is called the Side Mine. At the top of Matlock High Tor the Shale appears; and above it, at Riber, the Grit Stone: and above these measures or beds, is the coal formation.

Hot water flows from two or three sources. They were discovered in cutting levels to drain the mines; but no care having been taken, in the first instance, to prevent the hot springs from mingling with the cold, they unfortunately become tepid before they reach daylight.

The Heights of Abraham, at Matlock, is a mountain of great interest, containing veins and fissures in various directions: numerous mines have been worked in it, and the famous Rutland Cavern is situated near its summit.—In many parts of this cavern, are veins of Lead Ore and rare Fossils. In one part the Toadstone forms the roof, otherwise these vast openings are situated in Limestone.

It is impossible to point out a walk more interesting to the Mineralogist and Geologist than round these environs. He will here find a great variety of interesting specimens, and reap much practical information from an examination of the veins of metal, the mines, and caverns, the strata and masses of rocks, that present themselves in all directions.

Description

OF THE

LAPIDARY'S APPARATUS,

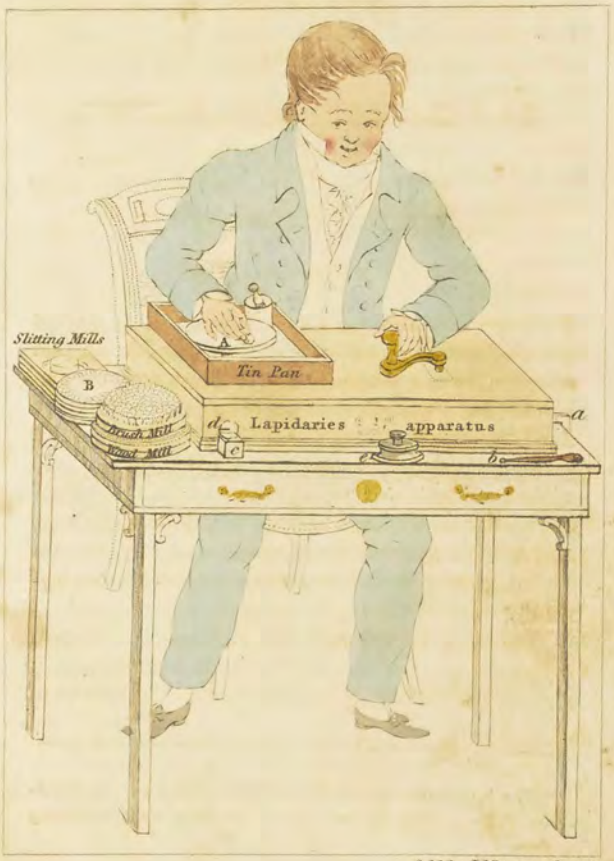
AND

INSTRUCTIONS FOR USING IT.

THE agreeable amusement of collecting prettily marked pebbles, agates, &c. has of late become so general, that almost every one who visits the sea-coast, has been employed in searching for these interesting productions, and forming collections of their beautiful varieties: but great disappointment has frequently taken place, owing to the Collector's not having the means of cutting and polishing them. To obviate which, a Portable Mill* has been contrived, so as to render the operation as easy as possible, and to afford both instructive and agreeable employment.

This compact Lapidary's Mill is contained in a small mahogany box, and may be placed on a parlour table, and worked without any inconvenience. The method of

* The Lapidaries technically call the various circular implements, Mills:—Thus the lead mill, the polishing mill, the slitting mill, &c.



Sold by J. Mawe, 149, Strand.

using it is explained as follows: viz. In order to proceed to work, the box must be secured to the table with the cramp *a*, (see the plate), that it may be steady; a varnished tin pan, with a hole in the centre, accompanies the box, which is to prevent the operator's dress from receiving the water and emery, thrown off from the mill when at work; it holds also the emery pot and brush.

The box being secured to the table, place the tin pan over the spindle, and screw on the LEAD MILL, marked A*, (holding, at the same time, the pully within the box with the left hand, to prevent its turning); place the pot, containing a mixture of fine and coarse emery and water, in one of the corners of the pan, and charge the mill, by laying on the emery with the brush. Then turn the handle with the left hand†, and apply the stone to the surface, moving it at pleasure farther from, or nearer to the centre, taking care not to press so heavily as to impede the velocity.—To perform this with ease and convenience, the right hand and arm must rest entirely on the edge of the pan, which will keep it steady, and allow a more extensive use of the fingers to change the position of the stone.

The mill works best when turned with considerable velocity, in which case it will be necessary to dab or renew the emery often, which is easily done, turning with

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* This mill should be *hacked* in the same manner as directed for the polishing mill *p.* 104 before the Emery is applied.

† The mill may be turned either way, but lapidaries usually turn it from left to right.

more velocity for a moment, and at the same time applying the emery brush, catching again the handle before it has made many revolutions.

After a stone has been thus applied half a minute, a plane will be worn down; and if a large flat surface be required, it will of course take more time.

The emery SETS in the lead mill, and produces a surface upon it harder than the stone applied, which it consequently wears away by friction. The emery, at the same time, requires to be frequently renewed.

When the stone is intended to be rubbed down, *(flattened)*, if sufficiently large, it is advisable to hold it in the fingers; but if it is small, it should be cemented (with resinous cement) to a stick (as *b*), or a piece of wood, of the most convenient form, from which it may be removed at pleasure, by warming the cement.

The lead mill will rub down stones of every class, though it makes but a feeble effect on the Sapphire.—What are termed precious stones, as rubies, emeralds, amethysts, &c. are seldom so large as to be held in the hand whilst cut or worked into facets; they must therefore be cemented to sticks as before described.

For cutting what are termed *Oriental Stones*, (as the sapphire, ruby, or topaz), it will be necessary to use a beaten copper or brass mill, instead of the lead one.

The POLISHING MILL (B) must be properly prepared, *hacked*. This is a singular operation, which is performed by holding the edge of an *old* knife perpendicular to the surface, and turning the mill, first one way and then the other, so as to produce the greatest inequality, or rough-

ness; it will then hold the rotten stone, which may be applied to it with a few drops of water. Great care must be taken that emery does not touch this mill, as it will spoil it. The stone may then be applied in the same manner as upon the lead mill, and by turning with considerable velocity, it will almost instantaneously receive a polish, especially if the facet be small.

Before the stone is applied to the polishing mill, it may be as well to work it a little upon the wood mill, with flour of emery and water; this will remove any coarse marks, and prepare it to receive a better polish.

In performing the operation of slitting, it is best to cement all stones under an inch in size, to a square bit of wood, (as *c*), which should be of such a height, that, when placed upon the pan, the stone (*d*) may (where it is intended to be slit,) come in contact with the edge of the slitting plate, to which it may be applied with a slight pressure; or if necessary, a moveable lever may easily be constructed, by which the stone may always be kept close to the slitter. By having small blocks of wood, of different heights, a slice may be cut of any thickness.

These mills are sufficient to cut, slit, and polish pebbles of every description; but other mills are added for various work, for which the apparatus is so well adapted.

A brush mill, to polish shells; which may also be used for all purposes where a brush is wanted.

A list mill (to be used with putty a little wet), for polishing soft substances with unequal surfaces, particularly shells.

A mill covered with cloth or leather, which is also

to be used with putty, to polish flat substances, as marble, spar, &c.

A copper mill, for slitting with coarse emery; this will cut or saw all marbles and stones that do not give fire with steel.

A spare wood mill, applicable to various purposes.

The iron slitter is to be used with pounded diamond, and a constant supply of very thin oil. The great art of corning the mill is as follows: when the diamond is properly broken, about a quarter of a grain should be put upon a steel block, or smooth stone (as *e*) with a *small* drop of oil; it should then be rubbed a little with the muller, in order to separate the particles of the diamond: in this state some will adhere to the muller, which may be applied to the edge of the slitter, in the manner hereafter stated, viz. hold the plane of the muller upwards, and apply it horizontally to the edge of the mill, which should be slowly turned, and the muller moved so that the edge of the slitter may take off a third or half of the powder upon it. This done, replace the muller on the steel, and gently apply any hard substance to set* the diamond, which will be imbedded in the edge, and form teeth; then apply whatever is intended to be cut, using a copious supply of oil. If the mill does not cut well, more diamond must be applied, until it is well *corned*. A saucer or pan should stand with oil, with which the mill should be constantly supplied, by lading it on with

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* A small steel roller may be advantageously used for setting the Diamond in the edge of the slitting plate.

a feather. The learner, after he has slit one small pebble or crystal, will afterwards find but little difficulty in arranging the tools for work. But I confess myself at a loss to find words to explain to the learner what he would so easily attain in half an hour's practical instruction, which would assist him more than a volume of letter press.

Shells may be uncoated on the lead mill, or on the wood mill, by applying sand and water to it.

This mill makes an excellent substitute for a grindstone: it is also useful in smoothing the surface of any substance applied to it, (with flour emery or fine sand), before it is polished, These mills are applicable to various purposes, particularly the sharpening of iron tools, cleaning rusty iron, brass, &c. &c.

The lead or wood mill may be used as a potter's wheel: a piece of properly tempered clay placed upon either, may be formed into a cup, vase, &c. A lady made a breakfast service by means of this apparatus.

Cotton strings, or twisted list, are to be preferred to any other, for turning the mills, because they are much more easily managed than cat-gut, and do not require hooks and eyes.

The expense of this apparatus, with a supply of emery, putty, and rotten stone, will cost from six to eight guineas, according as it has more or less tools: some are made with extra mills, hooped with lead, as high as ten pounds. It is particularly recommended, that those who purchase or make use of them should see a practitioner perform ALL the operations, by way of instruction. Every operation

in the lapidary business may be performed on this small apparatus in the most perfect manner.

GENTLEMEN who work a great deal, should have another tin pan, on purpose for slitting with oil. When the brushes are used, if they are above the edge of the pan, it must be elevated, or one with higher edges used; the expense of which is not more than two or three shillings.

THE END.

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FINIS.

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