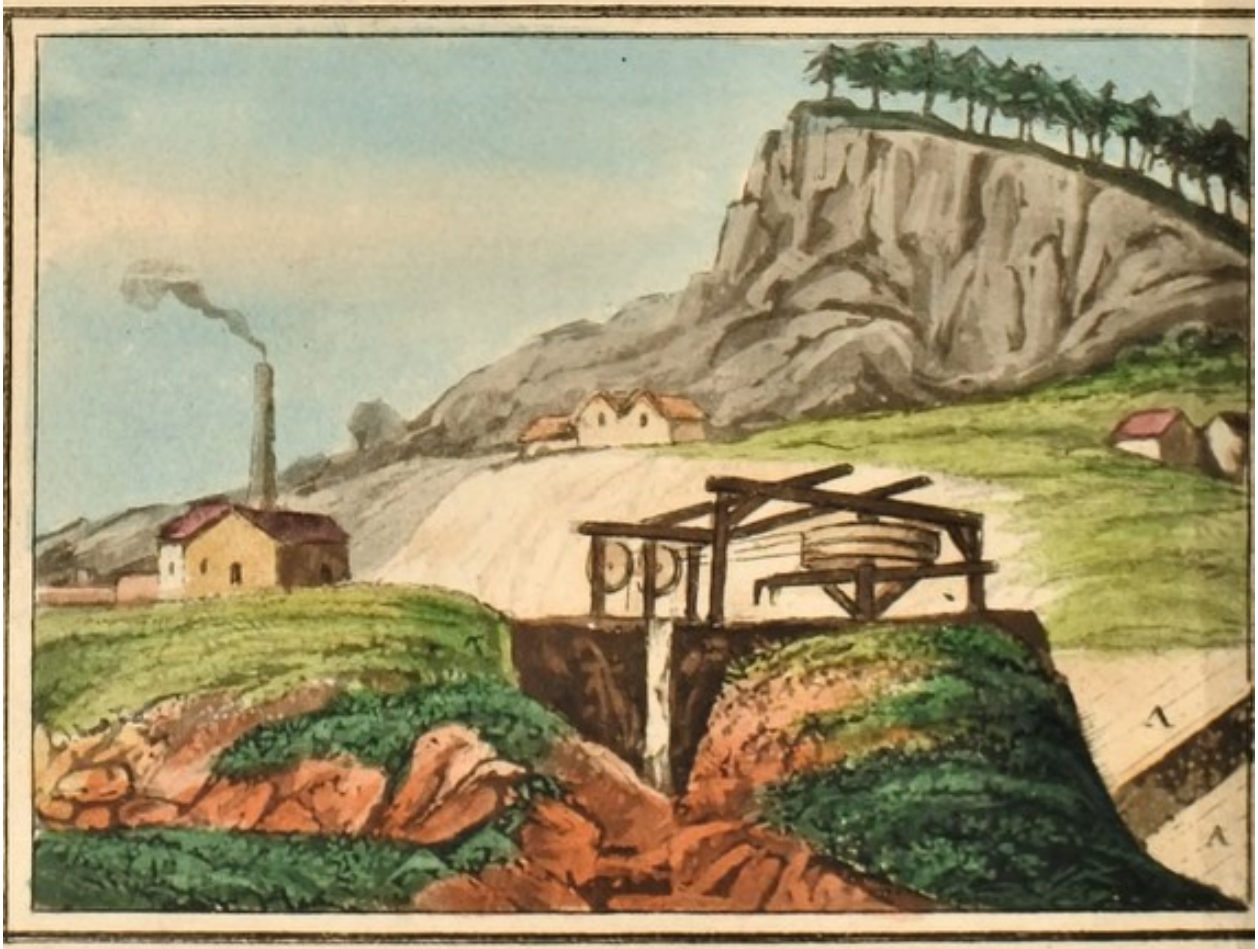
Familiar lessons on mineralogy and geology ... To which is added a practical description of the use of the lapidary's apparatus / [John Mawe].

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,

Honorary Member of the Mineralogical Society of Jena, &c.
Author of Travels through the Gold and Diamond Districts of Brazil; Treatise on Diamonds and Precious Stones; New Descriptive Catalogue, &c.

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

TWELFTH EDITION.

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PREFACE.

IN preparing for publication the present Edition of the LESSONS ON MINERALOGY, it occurred to me, that it would be interesting to the Student to have a short enumeration of those substances, described in the ensuing pages, which are more immediately connected with commerce and the arts, and most likely to engage his attention whenever he moves abroad, for to the Student in Mineralogy—

"No rock is barren, and no field is waste,"

the pavement of our streets, the most uncultivated and barren moor, afford ample scope for investigation and amusement.

THE substances which compose the subjoined list may very properly be classed under the title—

USEFUL MINERALOGY,

as it comprises the Minerals which are of the greatest importance in their application to the arts, and consequently most valuable in a commercial point of view. It may also have the additional advantage of stimulating the incepting votary of the science to pursue his inquiries, when he finds how limited is the number of substances to which it will be more immediately necessary for him to devote his attention, and at how small a cost* they may be obtained: for it has fallen within my own experience to meet with many whose ardor for the science has been repressed by the anticipation of the labor requisite to peruse voluminous works, and to understand the minute distinctions in crystallography; while to others the cost of select, brilliant, and elegant cabinet specimens, became a matter of serious consideration. But I am happy in having been able to convince them, that the latter are not necessary; and the rapid sale of 10,000 copies of these Lessons may prove to the reader, that he may be initiated into a knowledge of Minerals without the aid of the former. Many of these publications, however, are of great merit, and justly entitled to the praise of the learned connoisseur, who can follow the numerous

* Instructive collections may be purchased for two guineas.

diagrams with continued delight, and become interested in the pleasing perplexity of Crystallography.

To afford to the reader the means of discriminating the substances which are daily presented to his notice, by delineating their general characters, without fatiguing his mind with tedious descriptions of endless varieties, was originally my inducement to compile these Lessons.

Of the importance of a knowledge of Mineralogy to the Land-holder, the Artisan, and Merchant, the fact, that for years lime was exported to the colony of New South Wales, when it existed in abundance upon the very spot on which it was deposited; that our mines afford employment to an immense mass of population; that mineralogy is connected with almost all our manufactures; and that brass filings were bought for gold by the early visitants to South America; are satisfactory illustrations.

The beginner will more readily attain a knowledge of Minerals, by availing himself of the aid of Chemistry, which will not only afford him additional amusement, but greatly facilitate his inquiries—the Acids dissolve the Metals, which may be precipitated in various forms, in small glass tubes, and watch-glasses, as described in the following pages.

The assistance of the blow-pipe is indispensable in the examination of Minerals, and its importance cannot be too highly appreciated by the Student; for, by blowing through it across the flame of a candle, such an intense degree of heat is instantly produced, that small particles of Gold, Silver, Copper, &c. may be fused with facility, when placed on charcoal, and held in contact with the point of the flame. The experiments made with this little instrument are particularly interesting, and being performed so immediately under the eye of the practitioner, he cannot but observe the most minute changes which take place on the application of heat, the vapors that arise, and the color of the slag produced, (more particularly when borax is used), all which elucidate many important facts. The whole of the materials necessary for such examinations may be contained in the space of a tea-caddy.

LIST OF THE MOST USEFUL MINERALS,

AND THE NUMBER OF SPECIMENS REQUISITE TO SHEW THEIR DISTINCTIVE CHARACTERS.

Platina—Used in the arts.—A few grains.

Gold—Chief circulating medium—Used in the arts.—2 Specimens.

Silver—Circulating medium—Used in the arts and medicine, in various ways.—3 Specimens.

Mercury—Used in the arts and medicine.—2 Specimens.

Copper—The lowest circulating medium—Extensively used in the arts and medicine.—6 Specimens.

Iron—The most valuable of metals, in regard to its use—It is applicable in a thousand shapes, forms various branches of commerce, and is much used in medicine and the arts.—6 Specimens.

Tin—Used in the arts, and forms many distinct branches of commerce.—2 Specimens.

Lead—In common use, forms various branches of commerce—Is greatly used in the arts, medicine, &c.—4 Specimens.

Zinc—With copper forms brass—Employed in the arts and in medicine.—2 Specimens.

Cobalt—Of great value as an enamel.—1 Specimen.

Manganese—Is much used (to extract oxygen) in the arts, and forms a considerable branch of commerce.—2 Specimens.

Antimony—Is a component of types for printing; and is variously used in the arts and medicine.—1 Specimen.

Arsenic—Generally united with sulphur and iron—It is used in the arts and medicine.—3 Specimens.

The above are the most useful metals. The remainder, though important, are by no means so valuable or extensive in their application.

EARTHY SUBSTANCES form by far the most numerous class of Minerals; but the Earths most prevalent are only five; and of these a brief notice will suffice.

Silicious—Is a component of a very extensive class of substances, as quartz, chalcedony, opal, &c., and is much used in the arts, especially in the manufacture of glass.—5 Specimens.

Argillaceous—Used in the manufacture of porcelain and earthen-ware, and forms a very extensive branch of commerce. It is the base of most of the precious stones; and forms clay.—4 Specimens.

Calcareous—Lime-stone, the material of our edifices and the great stimulus of agriculture, constitutes a most important branch of commerce.—4 Specimens.

Magnesian—Imparts a greasy feel to the substances that contain it. It is much used in medicine.—2 Specimens.

Barytic—Employed in the arts and medicine, but of limited use.—2 Specimens.

Strontian—Not hitherto applied to the arts, except in pyrotechny, the nitrate burning with a vivid red flame. 1 Specimen.

Zirconia, Glucina, Yttria, and *Thorina,* have not been made available to any useful purpose.

The *Salts*, as nitre, soda, borax, &c., are extensively employed in commerce; and

The *Inflammables*, as sulphur, coal (the great stimulus of our manufactures, and its trade the nursery of our navy), &c. are indispensable to the necessities of life.

The Diamond of itself forms a distinct branch of trade, in which it has been estimated that three millions are annually returned. Diamonds, the worst possible, totally unfit for jewelry, and as gathered from the earth, are worth, in a commercial point of view, at least ten times their weight in gold; and there is always a demand for them.

J. Mawe, 149. Strand.

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. Hematitic 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 imbedded .....
22. Orbicular Granite .....

EXPLANATION OF PLATE (A).

(To face p. 106).

Exemplifying the Technical Terms used by Lapidaries.

A. The Mill with gimp-peg, the stick and stone in place on the mill.

a The Table

b The Bizil.

c The setting edge.

d Upper step. *d* Middle step. *d* Lower step.

e e e Ribs.

f The Collet.

1 Round, or tallow drop, as tops of ear-drops, or beads.

2 Oval tallow drop, as brooch-stones, seals, &c.

3 Octagon; when the corners are rounded, it forms the French oval, or cushion-shape.

4 Table stone cut with a setting or water edge.

5 Oval, with beveled edges.

6 Stone cut and formed for steps, ribs, brilliant-work, &c.

7 Block, often used for swivel rings, &c.

8 Step cut.

9 Block.

10 Single brilliant, with steps.

11 Double brilliant, with split facets on the bizil.

12 Full top stone.

13 Upper part of fig. 10.

14 Upper and lower part of fig. 12.

15 Rose cut, with split facets.

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 (*see p.* 38), 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, and to arrange and describe them.

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 of it 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. 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 could 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 classic 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 the following questions.

I.—HOW CAN I KNOW THAT THIS IS LEAD ORE?
II.—OR THIS PYRITES, WHICH RESEMBLES GOLD?
III.—OR THIS ROCK CRYSTAL?
IV.—OR THIS CALCAREOUS SPAR?

IN reply to the first of these questions—Observe its blue color, and remark its great weight, in both of which it resembles common 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 vapours, 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.

Quest. II.

HOW CAN I KNOW THAT THIS IS PYRITES?

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 mal-

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* The knife is indispensable in the examination of Minerals--i detects the degree of hardness and brittleness, the color of the powder, &c.

† 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 Gold. Brazil, Rio de la Plata, Africa, &c. can testify the mistakes many merchants and travellers have made by not being able to discriminate it from the precious metal. This substance is often called Mundic, Brazil, and Marcasite.

leable; neither of which properties is possessed by Pyrites, which is, on the contrary, brittle and hard.

Also, 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 colour; 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 ball of scoria, which will be attracted by the magnet; these effects prove that the Pyrites is a combination of Sulphur and Iron.

There is, however, another very interesting method of detecting it, which forms one of the many beautiful experiments that 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 it is Pyrites, considerable agitation, effervescence, and change of color, will be the result; which shews that the substance has been dissolved more or less by the acid. If this solution be thrown into a glass of water, and a few drops of the test for iron (prussiate of potass) be added, the liquid will assume a beautiful blue color.—The iron contained in the Pyrites, being dissolved by the acid, and held in solution, is as it were regenerated by the test, and precipitated in the form of Prussian blue; after which the water again becomes perfectly clear.

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

Quest. III.

HOW AM I TO KNOW THAT THIS IS ROCK CRYSTAL?

Apply the point of a knife; and if it makes no impression, it may be suspected to be quartz.

Rock Crystal, when pure, is perfectly transparent, but 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; it always scratches glass, and is often used for writing upon it. 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. This substance and Calcareous Spar are the most common in mining districts, and are frequently confounded with each other.

Quest. IV.

HOW AM I TO DISCOVER THAT THIS IS CALCAREOUS SPAR?

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), apply the point of a knife, and if it is brit-

tle and easily acted upon, and a white powder produced, it may be presumed to be Lime.

It also may be discovered by placing a few fragments on a hot fire shovel, when they will become opaque, and burn to Lime; which may be known by its styptic taste, or by its falling to powder with a hissing noise, when a particle is dropped into a glass of water.

Calcareous Spar exhibits a smooth, glass-like, shining surface; when broken, the fragments are of a rhombic form; it effervesces with acids, even with strong vinegar, if dropped upon it when reduced to powder; if 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.

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 author's "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 the whole country does not contain one subterraneous excavation! What is there termed a mine, is the bed of a river or bottom of a ravine, or some peculiar place 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.*

A ravine has lately been discovered, at Gongo Soco, near Villa Rica, which is filled with an auriferous deposit, with iron in great quantity, earthy matter, and alluvium.

This argues, that the particles of Gold have been dis-

seminated in the mountains, and, on the decomposition of the rocks, have been washed down by heavy torrents of rain to their present situation. It is common to see Pyrites *dispersed* in Limestone Rocks, and I have some specimens where Gold, in grains, is so distributed both in Jasper and Granite.

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

Particles of Gold are sometimes so extremely delicate, that they will float on water; another variety is so small, that it cannot be separated from the accompanying heavy earth and 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 as is the nearest to it in color, and not unfrequently with *brass filings*, which the merchants appear not to know how to detect: 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 re-

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* See Frontispiece.

† The negroes often bring from the interior their scanty earnings in the hollow of a quill to sell to the factors.

spect 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.

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 Nitric acid upon it; 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, but in a less degree; and if the experiment be repeated till all effervescence ceases, it will finally leave the Gold-dust pure*. This easy method of purifying Gold should not be unknown to gentlemen who travel.

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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 Blowpipe, Chemical Tests*, &c."

PLATINA.

IS found also in grains, accompanying Gold; it is heavier than granular gold, of a white color, and resembles silver; hence it is called Platina, the diminutive of *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 all other metals.

SILVER.

AS Silver has been met with in various parts of Cornwall and Devonshire, and in the Ochill hills in Scotland, 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 also occurs massive and branched in strong ramifications, or leaf-like; also penetrating Spar and other substances, in long serrated, wire-like branches, detached or connected, and frequently interwoven, like net-work. These silvers have often a fine rich metallic ustre, 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 slightest blow of the hammer; it melts into a beautiful white globule.

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

Ruby Silver, so called from its red color, is the most beautiful of the ores of this metal. It occurs disseminated, in a varieity 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. although it has not the least appearance of a metallic substance.

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 me-

tallic 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 will become coated 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, are easily evaporated. The two former may be detected by their smell; 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 quickly 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, it being the only metal which is found naturally in a fluid state; it exists in this state in semi-indurated Clay, in sandstone, and other earthy productions; it also often occurs in small or large globules, commonly attended with a red substance. 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 blow-pipe, when the Mercury will exhale in white fumes, which may be condensed on a plate of gold, as a sovereign, or a piece of bright Copper, as a halfpenny, held over the vapor; the plate 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, but 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 so much resembles the 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 if the solution be thrown into a glass of water, 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 than Iron Pyrites. The richer Ores are of a Gold yellow color; some are beautifully iridescent, 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 tint 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 coloured 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, which may always be detected by the preceding methods.

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 wonderfully displayed in the distribution of this most useful metal, and for which the ingenuity of man might in vain attempt to find a substitute. Almost all nature contains Iron.

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 varieties 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 student to learn 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 stated. This Ore of Iron is often disseminated in fine particles, in Spar, Limestone, and Coal: scarcely any mine is worked where it is not found. Other properties of Pyrites are described in pages 3, 4.

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 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 or radiated 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;* and 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, and are probably from the same source.

As Ores of Iron are continually undergoing changes by oxidation and deoxidation, their varieties are almost infinite.

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 so 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 particle 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 Chameleon, 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 dispersed in serpentine, 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 preceding.

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. 8): 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. and 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 zinc be immersed in the solution, the lead will be precipitated 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.

ONLY two distinct ores of this metal are commonly met with, *viz. Blende* or *Black Jack*, and *Calamine;* both of which present several varieties.

Blende is commonly black, brown, or yellow, of different shades; it is massive, and often appears in clusters (confusedly crystallized) upon the surface of other minerals; 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 strongly effervesces 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 loses about one-third of its weight; and if the heat be continued, it evaporates and 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 redissolved 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 experiment, 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 divergent 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 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 to 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 be sufficiently admired; it is a lesson upon attraction and affinity, which cannot fail to please those who have not heretofore seen it performed.

LESSON III.

TIN.

ITS GENERAL APPEARANCE, AND METHOD OF DETECTING IT.

TIN may be detected by placing 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 learner: 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 of ores, and the lightest of metals. It presents but 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 difficultly 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, called Stream Tin; and some have divergent striæ, and a ligneous appearance, hence called Wood Tin.

The ores of this metal are not easily reduced; after being exposed to a red heat, they should be pulverised, and mixed with soda and charcoal, and 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 one of the oldest metals, being 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, where it occurs in great abundance.

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.

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, Lead, Cobalt, and Nickel. As its varieties are very few, the learner will be easily 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 ramifications,

of a polished steel color, often appearing map-like: 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 folia; they both yield to the knife: 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 commouly contains Selenum, which may be detected by exposing a particle to the flame of the blow-pipe, when it will emit a pungent fume, not unlike 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 Printers' types, in Medicine, and other purposes. It may 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 iridescent colors. It has generally a shining bright appearance, resembling Lead Ore; but it more commouly 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 disseminated 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 working. 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 of a peach-blossom red color; and others are dark and earthy, and sometimes of various colors, (owing to the intermixture of other metals), as black, blue, and green, the latter varieties often occur in Sandstone. The best Cobalt is produced from the Saxon and 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. Cobalt has also lately been found in Clay Slate in Cornwall and in Grit Stone in the alluvial soil in Cheshire, accompanied by Carbonate of Copper, Manganese, and ores of Lead.

Many amusing experiments may be made with Cobalt, which Parkes's excellent Chemical Catechism explains.

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 often accompanied by Copper, and is also combined with Meteoric Iron.

Nickel is massive and compact, not so dark as Copper, though approaching it. It is hard, not easily scratched by the knife, and is very heavy; any further description would avail little, as the characters before described are sufficient to distinguish it from any other substance. Fragments produce a fine apple green color in nitric acid. It melts rather difficultly, emitting arsenical fumes that smell like garlic. From this description the learner

cannot 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. Under the blow-pipe it melts instantly, and evaporates, emitting white fumes abundantly.

It presents great diversity in appearance:—when it occurs in a *native* state it has a tin white color, with metallic lustre, also sometimes a dark color approaching black; its fracture is conchoidal. 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. 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, in being harder, and not effervescing with acid, to which, however, it imparts a yellow tinge.

Wolfram is a common mineral in Cornwall, though hitherto of very limited use. It is of a dark color, approaching 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. 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 concre-

tions 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 found at Fahlun in Sweden.

Selenum is suspected to exist in other minerals, but its rapid volatilization renders it difficult to be observed; 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 arizes, 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. In what manner the minerals have been deposited in these receptacles, is yet considered doubtful, there being 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 having been produced by sublimation; having first premised a description of the veins in which they are found, and of which there are many varieties.

Some fissures appear to have been 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 vary from sixty to a hundred feet wide in certain parts, and are 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 interrupted by Calcareous Spar, Barytes, Fluor, Blende, and Pyrites. The Lead Ores in the Primitive rocks contain a much larger proportion of Silver than the 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 to the depth of 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 irregular in their direction and magnitude, and appear like a series of caverns, connected with each other. The top, bottom, and sides are lined, (and sometimes filled), with Spar, intermixed with Pyrites, and great abundance of Lead Ore, and its attendants, Fluor and Barytes: some of these veins have produced a vast quantity of both Lead and Copper*.

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* A cavern was lately discovered near Crich in Derbyshire, on the estate of — Nightingale, Esq. which was estimated to contain a thousand tons of Lead Ore.

Derbyshire presents a great diversity of surface; the high mountains and deep ravines exhibit the strata, the stratification, and the veins, in a most instructive manner, particularly in the neighbourhood of *Matlock.* It is worthy of notice that Lead Ore is met with in *nests*, filling caverns in solid Limestone: and even penetrating the entrochite and fossil shells!

Lead is found below the Coal, the strata of which are generally composed of various sorts of Grit, which lie above the metalliferous Limestone, and are allowed to be a later formation. It sometimes occurs in the Coal formation, as near Hazlewood in Derbyshire, and near Whaley Bridge in Cheshire.

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

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 of almost every class.

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, as before observed, that several metallic ores, with their associates, line the roofs and sides of caverns, evidently deposited there by infiltration, as is clearly demonstrated in the Derbyshire pipe veins.

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 gaseous 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 repostiories 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—Attraction 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 law.

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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 solid Gold*. The most productive mine was in the alluvial soil,

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* The author lately possessed a specimen of Gold above 30 oz. in weight; and has the finest Crystals of that substance hitherto seen.

under a thin stratum of Micaceous Iron Ore, where Gold, in delicate folia, was intermixed with it*.

Platina, though more rare, is found in the same manner as Gold, by washing the soil.

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 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 and Peru, where above forty millions of dollars have been annually coined: the author possesses a specimen above 10lbs in weight.

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: one mine lately produced annually upwards of £10,000, in silver.

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* A fissure in a rock, of greater or less extent, is sometimes discovered completely filled with auriferous earth. This is decidedly an alluvial deposit.

Tin, Copper, Lead, &c. are extracted from veins of larger or smaller magnitude. These Ores are frequently very difficult to work; 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 that 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, as before stated.

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

How confined formerly must 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 to 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 Slay, particularly in Cornwall, where they are as-

sociated with Quartz; but the great mine of rich Copper 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 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 a 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 perfectly 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 innumerable individuals 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 recognize 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, should 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 silicious, and consist of rounded pieces of quartz, jasper, chalcedony, &c., which will be described in order.

How many have picked up 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)*, which they may have found, 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; those generally offered for sale, in the rough state, from Brazil or India, are seldom 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 the substance be small, place it betwixt two penny pieces, and strongly press them with the thumb and finger, when, if it is not a Diamond, it will break and be reduced to powder; 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 Sapphires, and Chrysoberyls, White Topaz, or Minas Nova, resemble the Diamond more than Crystal; but the Diamond cuts them with the greatest ease, and they may be broken by 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 pre-eminent 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 rounded by attrition, hard, and silicious, as Quartz or Crystal, already noticed. They give fire when struck against steel, do not yield to the knife, and, when broken, have generally a shining, curved, uneven fracture; the fragments are splintery and sharp edged.

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

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* See the Author's Treatise on Diamonds and Colored Stones.

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; the Egyptian variety presents also curious resemblances of *Lusus Naturæ*, some of which are highly valued.

Jasper is of a fine texture; its exterior appearance is smooth, and often strongly colored. It often occurs in veins and patches in the Primitive rocks. It is very hard, tough, and difficult to break, and contains a large portion of iron, particularly the red variety. It decomposes into Clay.

CHALCEDONY

OFTEN occurs rounded amongst the pebbles of the seashore: it is of a very close texture; fracture, not shining; color, generally pale milk blue; translucent; is often marked by straight opaque white lines parallel to each other, and frequently resembles white carnelian. It has every appearance of being formed by deposit. It occurs in thin strata, also stalactitic, and is abundant in volcanic countries.

AGATE

IS a substance so generally known, as to need but little description: it is particularly beautiful when cut and polished. Agate commonly consists of Chalcedony, Quartz, and Jasper, in angular and concentric lines; the Crystals of Quartz, which frequently occur in the interior,

tend to shew that it has been formed by the infiltration of silicious particles, at different periods, into pre-existing cavities: it owes its colors probably to iron or manganese. The agate has a rough exterior, and is often spheroidal, frequently indented, and generally of a dirty green color. It is found in detached nodules in Green Stone and other rocks.

A mere sight of these substances will so impress the mind of the learner, that he will not require more information than may be obtained by 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 Gravel, 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 having once 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. It frequently occurs in a state of decomposition, and forming clay.

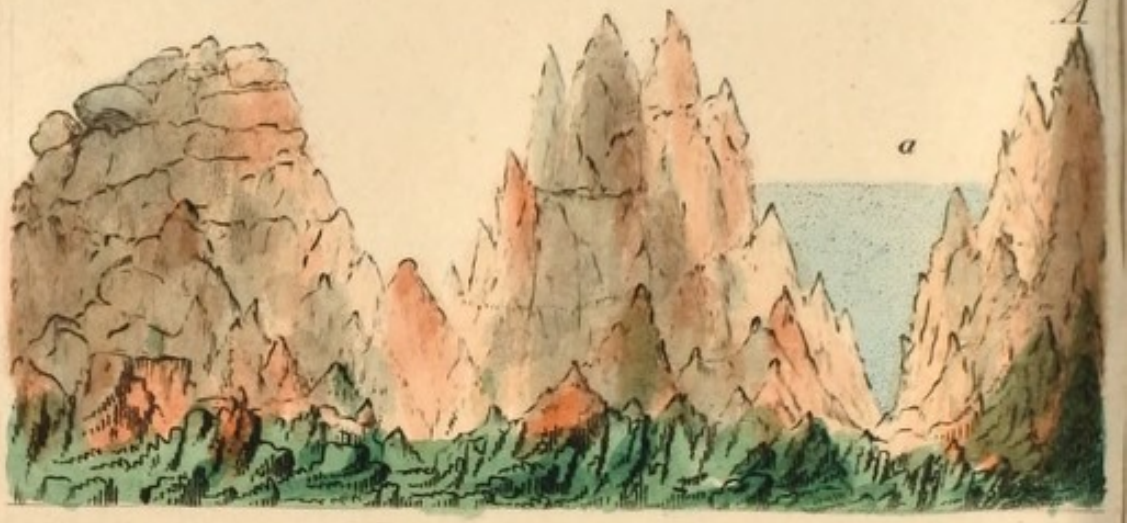
PORPHYRY

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, and frequently exhibit regular forms. Porphyry is often met with in a decomposing state; it is then much softer, and finally becomes clay. There are great varieties of Porphyry, some of which are much harder than others.

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.

A



Primitive Rocks.

B

Primitive Rocks & Secondary.

Stratified Rocks. Floetz Formations and alluvial deposit.

J. Mawe. 149 Strand.

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. *Silicious, Calcareous, Argillaceous, Magnesian,* and *Barytic;* to which is added the *Strontian.* None of them

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

have hitherto been met with in a state of purity, being 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 appearance.

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 has thought fit to present it to our view.

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

Silicious Earth or Silex ‡ occurs in great abundance in GRANITE, which is composed of QUARTZ, FELSPAR, and MICA. These substances are sometimes distinctly

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* Zirconia exists in the Zircon; Glucina in the Emerald, Beryl, and Euclase; Yttria, in the Gadolinite; and Thorina, in Cerium.

† *Silicious, 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.

crystallized, but generally confusedly aggregated; they are allowed 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, and is the general constituent of Alpine countries: there are frequently immense tracts of various formations betwixt its lofty rocks, 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 distinguished from its associates, *Felspar* and *Mica*, by observing the characters of each. Some varieties of *Granite* are very small grained, consequently the component parts are more difficult to be

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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.

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, irregular, not of any determinate form; it is sometimes imbedded in massive Felspar, and, when broken across, resembles Hebrew characters. It is commonly inclining to opaque

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* Silex consists of Silica and Oxygen, the latter in the greater proportion; Berzelius states it at 54 per cent. Oxygen forms also 84 per cent. of water, and 23 of atmospheric air. It 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. It also in the same manner combines with Copper, and forms what is termed Verdigrise.

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

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

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, as in the Amethyst. 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. partake largely of this substance; it composes the very numerous and extensive class called Sandstones, coarse and fine, and of almost every denomination, whether in rocks, or reduced to pebbles or gravel, to large or small-grained sand, or to the finest particles called dust, in which state it floats in the air, 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, also blue and green. It is sometimes transparent. Labrador, or iridescent Felspar is very beautiful; it is massive, and exhibits a great variety of colors in the same specimen.

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* Felspar contains a portion of Potass, which causes it to decompose, when it forms Clay; this alkali, meeting with Iron in the state of an 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 folia, thinner than the finest 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 glazing 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 is a Magnesian earth, and contains a portion of Iron, Manganese, and Soda.

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 in great variety, but generally of a dull dark color, bluish black; it is 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 Felspar 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 much intermixed with Hornblende, which is frequently in minute particles, yet the Felspar may be distinguished by its lustre and flaky appearance.

It is often very difficult to determine many of these substances by an examination of detached specimens.

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

These substances, when decomposed, (to which they are all subject), form Clay. The Felspars produce the finest, which is used in the manufacture of China and the best earthenware. Clay-slate, Shale, and the coarse varieties, when decomposed, are used by potters, and in 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.

PRIMITIVE 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. Beautiful, pellucid Rock Crystal is often found embedded in it.

Limestone 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.

But in the Floetz or Flat Formation, Limestone is very generally distributed, forming mountains comparatively of less magnitude than the primitive, also valleys and

plains; it exhibits regular marks of stratification, shewing evident signs of an aqueous deposit at different and distant periods, and appears 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 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 form of the marine exuviæ, of which they are composed.

The black marble is most esteemed; the best is found in Derbyshire, near Ashford, where mills are erected for working it, as well as 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 of great use in the arts; when burnt, it forms Plaster of Paris, and is cast into busts, mouldings, flooring, &c.

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

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 various Limestones.

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* Lime, combined with Fluoric Acid, forms the interesting fossil called Fluor-Spar; 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 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 often 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, Amygdaloid, 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; 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.

CARBONATE OF BARYTES is more rare than the preceding. It has generally a striated and diverging fracture; is very compact, and, like common Barytes, may be known by its great weight; it effervesces in diluted acids.

SULPHATE OF STRONTIAN.

STRONTIAN COMBINED WITH SULPHUR.

STRONTIAN is an earth newly discovered; it resembles Barytes in some particulars, but 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 crystallized, granular, fibrous, and earthy.

CARBONATE OF STRONTIAN.

STRONTIAN COMBINED WITH CARBONIC ACID.

ANOTHER substance, called *Carbonate of Strontian,* is green or brown, and 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 fine 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 crys-

tallized and earthy, in great quantities, considering it is produced only from veins.

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, and has lately been found in Shropshire.

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

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

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 considered the oldest, *Primitive Rocks*. Thus, those

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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.

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

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 with a general and brief description of some of its varieties.

Although the crystals of *Quartz*, *Felspar*, and *Mica*, are generally in this substance 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 notice them separately.

Quartz occurs crystallized or massive.

Felspar. Crystallized and compact, having a foliated structure, and an 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 of Dartmoor and Scotland.

Granite, common variety, neither large nor small

grained, being composed of Quartz, Felspar, and Mica, in regular proportions.

Granite, small grained, color generally grey; sometimes 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 (which forms the base) and the Quartz are easily distinguished; the Mica occurs in distinct thick patches.

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

Granite, the Felspar of which is disseminated and decomposing, or quite soft, forming Clay; the Mica and Quartz appearing unaltered*. It is common in Cornwall, where it is washed, and the clay separated.

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 Por-

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

phyritic Granite; the streets of London are paved with it, and the crystals of Felspar (particularly after rain) may be seen protruding above the surface. This variety differs much in the proportions of its constituents; it frequently contains Hornblende, and the finer variety 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 a variety of 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. Garnets often associate with it.

Another variety is, by some Geologists, called *Gneiss,* when Hornblende forms a constituent, although it is not stratified.

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 is extremely vague, and depends much on the color.

Topaz Rock, in appearance, resembles Gneiss, but consists of Granular Quartz, Schorl prisms, Topaz, and Lithomarge (Clay), generally stratified. Topaz and Quartz are commonly crystallized on some part of it; 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 PRIMITIVE ROCKS were probably 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: many metallic veins occur in it, particularly Tin, Copper, and Lead; the latter is commonly rich in Silver. Clay

Slate is generally of a dark blue 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; crystallized Pyrites and Rock Crystal, beautifully defined, are frequently imbedded in it.

Flinty Slate is of a black color, hard and compact, and of fine texture; it is considered to be a combination of Hornblende and Silex; it contains numerous capillary Quartz veins. Lydian Stone is a fine grained variety; it is said to occur in beds, with Porphyry and Grau-wacke, and is not uncommon in the alluvium.

Porphyry. What is commonly understood to be Porphyry, is a hard, red-brown substance, containing crystals of Felspar, of a light color; this variety is called Red Egyptian Porphyry. Green Porphyry is of a dull dark green color, with light green crystals of Felspar, and spots of Chalcedony; the ancients called it Ophites, but the modern Italians, *Serpentino.* Brown Porphyry, from Sweden, resembles the Egyptian, but is not considered so valuable.

Jaspers, of various colors and characters, sometimes fill cavities in this formation, and constitute veins.

*Serpentine** is not very abundant in this country: when associated with Primitive Rocks, it is considered of

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* *Serpentine* is often spotted, and resembles the skin of Serpents, whence its name.

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 are more compact than others. After examining a few specimens, it may generally be known by its varied colors, and being always unctuous to the touch; when breathed upon, it emits an earthy odor; it is soft, easily scraped, and produces a whitish powder.

Native Copper is often found in this substance in delicate ramifications and foliated.

This stratum contains veins of Talc, Steatite, and Asbestos; also Magnetic and Titanious Iron Ores.

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. Other varieties are granular, compact, and slaty, which have been confounded with Basalt. In decomposition Trap appears highly ferruginous, and with numerous vesicles.

Green Stones, composed of Hornblende and Felspar, are considered by some geologists to 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 varieties of Statuary Marble; it is also found compact, as the limestone from Tiree; where it occurs of a beautiful flesh-red color, with Sahlite and Titanium imbedded; it effervesces with acid, and easily yields to the knife. Another variety from Scotland, has a clouded dull green color; it is of close texture, granular, and receives a high polish, it is often called Athol marble.

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, to have been split and separated in all directions: whether this has taken place from desiccation, internal combustion, earthquakes, or other causes, we know not, but they appear devoid of regular order, presenting rude, barren, perpendicular, and overhanging projections, with pointed elevations, of great extent. Such mountains may be supposed to be represented in plate A. which is intended merely

to give the learner an idea of rugged Alpine scenery. Thus a valley may be filled by a deposit of Blue Clay, Sand, &c. as (*a*).

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, Elvan, Porphyry, Jaspers, Whin-Stone, Hornstones, Green-Stones, Calcareous Spar, &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; as are those in Charnwood Forest; the Granite 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 rests upon the Primitive, and is called the Secondary: it 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, remains of which 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 chemical 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 extensive class of rocks of this series is considered to be formed by mechanical mixture or deposit, and may be compared to a bank of sand in the sea; another class is partially crystallized, and 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*; it 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 said to be highly metalliferous, *i. e.* contains metallic veins. Some varieties are much harder than others.

An examination of some well defined specimens of this substance would enable the learner to form a better

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

idea of it than description can possibly do, its appearances being so various.

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

Secondary Limestone is generally considered to be 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 Devonport* are paved with it. In the north of Devonshire, near Castle Hill, this variety of Limestone occurs, filling large cavities in Grau-wacke slate. It contains many Sparry white veins, abundance of Pyrites, and sometimes Lead Ore. Fossil petrifactions occur, but not of the same description, nor in any degree so abundant, as in the Limestone of the more recent formation.

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* The town of Devonport 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, ferruginous 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 exhibit a different appearance in every stage of decomposition.

Numerous Green Stones belong to this order; they are composed chiefly of Hornblende and Felspar; confusedly intermixed, 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, 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 contains 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; Basaltic, Hornblende, and Green Stone Rocks often appear one above another, forming steps, hence the term Trap. It is particularly visible at Staffa, and in various parts of Scotland, the Giant's Causeway in Ireland, and other places.

Rocks of this class decompose into strong ferruginous Clay; their exterior, being first acted upon, is frequently soft, while their interior remains unaltered.

Transition Flinty Slate is a silicious substance; which occurs in thin beds with Grau-wacke and Secondary Limestone; it is compact, and marked by alternate lines or veins of a dark or lighter color, generally white.

Grau-wacke is *said* to be the only formation of the Secondary class that is Metalliferous; many strong and large veins of Lead Ore are situated in it, 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, upon their bases, forming from their disintegration, and skirting them.

It is highly probable that the Secondary Formation is of greater extent than we have at present any idea of, and that more varieties will be ranked in it, when our ideas become unfettered by the existing theories and systems.

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 upon them by deposit *(chiefly mechanical)* from their disintegration and the debris of organic remains. It also exhibits evident traces of having been chiefly formed under water, at various epochs, and by various operations, which have filled, or rendered more flat, extensive valleys between elevated Rocks of the Primitive class. This order is very general throughout a great part of the globe, and must have undergone considerable alterations, as the visible confusion and irregularity of the strata plainly indicate.

I shall now endeavour so to explain the substances which compose this class, that they may be distinguished from others, and to state the generally 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*, with a section of a perpendicular vein of Lead Ore, *v*; and a flat or pipe vein, *p*.

The letters, *f*, *f*, shew the separation of the rocks, and the irregularities of surface in this Limestone; patches

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

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.

In the Coal formation are found 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 order, above it, following the Wernerean arrangement, is the first Floetz Limestone, *F L;* 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 supposed to be 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; but the exact situation of this stratum is by no means well ascertained.

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, and probably has never been 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 separated by some cause that has made the surface appear in great disorder, by which numerous metallic veins have been 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, Gryphite, and Anomiæ. 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 assign 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 consists of beds of considerable thickness and extent, and contains a portion of Clay, with Oxide of Iron and Mica. It is extremely 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 abundant in Derbyshire and Nottinghamshire, particularly near the river Trent; no metallic substances or 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, or the filling up of ravines, which are 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 considered of this formation. It is much used for building, and so soft, that it may be cut with a saw.

Rock Salt is clear and transparent, or coloured red and brown, rarely blue; it is situated in basins of grit-stone, 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 by thin beds of Limestone. It is found in great abundance at Northwich and Nantwich in Cheshire.

Chalk. This formation (supposed to be one of the latest of the Limestone class) occupies considerable space in this country, and rests upon what is termed Green 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.: it alternates with Sandstone, which often appears both above and below it.

In the valleys of the Chalk formation are large deposits (basins) 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 found a variety of fossil shells, &c. which indicate their aqueous formation.

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.

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 Limestone, Floetz Sandstone, and Bituminous Shale formations, and lies in strata, generally alternating with one of these, and commonly attended with a large quantity of Pyrites. It is, however, more frequently found in the Sand-stone formation, filling cavities or basins, and alternating with grit of various characters, sometimes laminated, and with Mica, which is often earthy when it approaches the Coal. The grit commonly contains nodules of Iron-stone, and impressions of vegetables carbonized, as ferns, &c., seeds, and branches of plants.

Compact Coal—Cannel 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.

Iridescent Coal is a variety of the *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. This variety is found a little below the surface, in long plank-like layers; it has a very perfect wood-like texture, and is of a brown color, rarely carbonized; it burns with difficulty, and emits a disagreeable odor.

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 the air from it, to complete the process.

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

NEWEST FLOETZ TRAP FORMATION.

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

Basalt is considered either homogeneous, or composed chiefly of black ferruginous clay; it is of close texture, and heavy, 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 or crystallized, together with Hornblende, and sometimes Quartz, Chalcedony, and Calca-

reous Earth. It is rather difficult for the learner to discriminate the crystals of Augite from those of Hornblende, until they have been properly explained.

It also exhibits a columnar structure; and its exterior is commonly porous (arising from the decomposition of some of the component substances), which in many cases gives it a cellular appearance, not unlike lava.

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

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.

Geologists are by no means agreed as to the nature of the substances which constitute this formation. Modern discoveries may perhaps remove some of the difficulties.

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 also the appearance of a volcanic origin. From Etna in particular 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.

From the vast quantity of Sulphur attending Volcanoes,

may it not be inferred, that an immense bed of Pyrites is always in fusion in the neighbourhood?

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, raised islands from the almost unfathomable depths of the ocean, ingulfed whole districts, and formed mountains where plains existed, separated rocks, and thrown them into the greatest disorder, exhibiting ravines and abrupt precipices, are frequent in volcanic countries.

There are immense silicious deposits from the hot wa-

ters of Iceland, resembling Calcareous Tuffa, in some of which are patches which common observers would take for flint, if the surrounding spongeous substance were 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 silicious 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

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* Of the deluvial we know but little—it may be classed with the alluvial.

it forms hills on the banks of the Derwent; in it are found Land-shells, Deer-horns, Bones, 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 vegetable fibres, until their channel 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 sometimes carry quantities of it away, having the appearance of 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, including what is termed by some writers the deluvium, 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 perused 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 assign their formation to any definite period, yet the structure of many of them exhibits distinct evidences of their relative age, as may be clearly seen in a small collection of select specimens: the Primitive Rocks exhibiting no traces of organic remains, which rarely appear in the Secondary, but are abundant in some varieties of the Floetz Formation. Hence it is considered that the Primitive formation was antecedent to the creation of animal and vegetable substances; the Secondary coeval with it; and the Floetz, subsequent.

Indeed, the formation of rocks is still going on; the zoophytes construct extensive coral reefs, resting upon, and covering those of a different quality, and of a prior existence, others again are formed by the accumulations on the coasts and mouths of rivers, influenced by tides, currents, gales of wind, &c.

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

Well may we exclaim, can any mind be so indifferent 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 dodecahedron of Garnet: then contemplate the laws by which these forms are produced in the mysterious laboratory of Nature, and we cannot but acknowledge the infinite power of the Creator.

CLASSIFICATION.

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.	Garnet.
Zircon.	Quartz.
Sapphire.	Pitchstone.
Schorl.	Zeolite.

Azurestone.
Felspar.
Clay Slate.
Mica.
Lithomarge.
Soapstone.
Talc.
Hornblende.
Chrysolite.
Basalt.
Dolomite.
Limestone.
Apatite.
Fluor.
Gypsum.
Boracite.
Barytes.
Strontian.
Hallite.

SALINE MINERALS—Earthy Salts.

Alum.
Epsom Salts.

ALKALINE SALTS—Salts of Soda.

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

SALTS OF AMMONIA.

Muriate of Ammonia.
Sulphate of Ammonia.

METALLIC SALTS.

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

INFLAMMABLES.

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

Description

OF

COLORED PLATE.

SEE FRONTISPIECE.

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

THIS PLATE is taken from a view in Cerro de Frio, in Brazil, which the author visited by royal permission. 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.

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

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* A bowl (*gamella*) of earth is washed in less than ten minutes.

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 it 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 show 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 shew 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 SecondToadstone, which formsthe 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. Two famous Caverns are situated near its summit. In many parts of these caverns are veins of Lead Ore and rare Fossils: they are situated in Limestone, except in one part, where Toadstone forms the roof.

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*.

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* The Museum at Matlock contains the general productions of the country in Minerals, Vases, &c. and every information may be obtained there, relative to the Mines, Caverns, &c.

Sold by J. Mawe, 149 Strand.

Description

OF THE

LAPIDARY's APPARATUS,

AND

INSTRUCTIONS FOR USING IT.

THE agreeable amusement of collecting pretty pebbles, agates, &c. has become so general, that almost every one who visits the coast, or goes abroad, searches for these interesting productions, in order to make a collection of their beautiful varieties; but great disappointment has frequently occurred from want of means to polish them: to obviate which, the author has invented a portable apparatus, whereby every operation of the lapidary may be performed, and *amusing employment afforded to the amateur.*

THIS APPARATUS is contained in a mahogany box, which may be placed and worked on a parlour table.

Various tools are employed in the different stages of the work, which are technically called *Mills.* The methods of applying or using them will form the subject of the following pages.

In order to proceed to work, the box must be secured to the table by the cramp (*a*), (see Plate). A tin pan, with a hole in the centre, accompanies the box, which will prevent the operator's dress from receiving the water thrown off by the mill when in motion; it also contains the water, emery, brush, &c.

To cut, that is, rub down, the surface of a pebble, so as to produce a plane, in order to examine its beauty, proceed thus:

USE OF THE LEAD MILL.

The box being secured to the table, place the pan over the spindle; screw on firmly the lead mill A, holding with the left hand the pulley within the box, to prevent a contrary action; place the water pot and brush in one corner, and the emery in another; this done, apply the wet brush to the emery*, and lay it plentifully on the mill; then turn the handle with the left hand, (from left to right)†, holding the stone on the mill with the fingers of the right hand, pressing moderately, and at the same time moving the stone nearer to, or farther from, the centre:—varying the pressure and position facilitates the grinding away the part required, in order to produce a plane or smooth surface. To perform this with more convenience, the right hand must rest entirely on the edge of the pan, which will not only keep it steady, but allow the fingers to be used more freely.

If a plane is to be produced, the stone must be held steady on the mill; but if a rounded surface is required, it must be continually moved in different positions.

Stones too small to be held in the hand, may be attached‡ to a piece of stick, (see (*b*), Plate); as must all stones that are to be cut with facets.

The first operation is, to produce a plane or uniform surface on a pebble, &c. this is called *roughing*, or *flat-*

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* Fine corn emery mixed with superfine is generally used.

† Lapidaries turn either way in rough work.

‡ Lapidaries' cement may be purchased where emery is sold.

ting: however hard a stone may be, a plane will be produced in less than half a minute; but if a large surface is acted upon, of course it will take a longer time. When brought to the required shape, it is fit for polishing.

EMERY being one of the hardest substances, sets in the lead, and hence a surface of emery is formed, which by friction will rub down any stone applied to it. As the emery wears at the same time, a constant supply is requisite. It is also to be observed, that when fine facets are to be cut upon amethysts, or any other soft stone, fresh emery is too coarse, and renders the edges of the facets rough. In order to fine the mill, lapidaries take a solid *piece* of emery, about an inch and a half square, with a flat surface, and apply it to the mill, whilst it is quickly turned for a minute, which will completely effect the purpose. This is called the emery stone. I have found a piece of agate answer the same end; but solid emery is best.

FLATTING, or roughing, is the first operation the young lapidary is put to; it is also the most laborious. After the novice has acquired some tact in the management of the mill, he is instructed in the art of cutting facets. A stone is said to be *roughed*, when it is worked from its rough state into the form required.

Having finished the work on the lead mill, it may be displaced, and the wood mill substituted, which is used as follows:

THE WOOD MILL.

THIS mill is worked with sand and water, or flour emery; it is very serviceable in rendering the stone smooth,

which prepares it for receiving a better polish; it is easily used, and requires no further direction. Carnelians, agates, jaspers, &c. worked on this mill, will receive so fine a surface, that they may be polished with great facility.

This mill being light, it is advisable to hoop it with lead, which will make it work more agreeably, and with greater ease. It is an excellent utensil for uncoating shells, cleaning rusty iron, brass, &c. as is also the lead mill for sharpening chisels, tools of all sorts, knives, &c. but it must be used with great care, and when the emery is worn very fine.

USE OF THE POLISHING MILL.

This mill (B) should be made of good pewter, and is of course harder than the lead mill. When new, it must be prepared by an operation which is technically called Hacking. It is performed as follows:—The edge of an *old* knife must be held, with a slight degree of pressure, nearly perpendicular upon the mill, whilst it is turned with moderate velocity, which will soon produce numberless concentric lines, and a degree of roughness; it must then be turned the contrary way, the knife being held nearly in the same position, until the greatest irregularity, or rasp-like roughness is produced by the intersections. This completed, the mill is then in a proper state to receive the polishing materials, and is fit for work*. As the smallest

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* Hacking the mill requires so much tact, that it is requisite for the beginner to see a practitioner perform it. The mill must be

particle of emery would injure the mill, the pan should be washed clean, or another pan (to be used solely for this purpose) placed over the spindle.

This done, place a pot with clean water in one corner of the pan, and a piece of wood a quarter of an inch thick and five or six inches long, cut in the form of a shovel, which is to be used to keep the mill wet. The rotten stone may be applied by first wetting the mill, and then holding a piece upon it whilst in motion, when a sufficient quantity will adhere and remain upon the surface, lightly covering it all over.

The stone to be polished, after having been washed, may be applied in a similar way as before directed on the lead mill; and by turning quickly, a high degree of lustre will be almost immediately produced. It is very encouraging to the learner to see how easily a *facet* or small surface receives a polish. If the stone is soft and porous, it will require more labour. When the mill becomes dry, apply more water and rotten stone: the little shovel is useful in wetting the mill and spreading the polishing substance evenly when necessary.

These directions are sufficient for *flatting*, *rounding*, or *cutting* stones with *bevelled* edges, cushion-form, spheroidal, seal or brooch stones, &c. but for facet work it is necessary to have a gauge, an instrument called a *gimp-peg*, to be used as was the quadrant of ancient workmen, for which it is substituted.

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made rough, in order that the polishing substance may remain on it. After much use it will wear smooth, and will require the same process to render it fit for work.

TO CUT FACETS.

In order to cut facets, or to put what is termed a course of regular work upon a stone, it is necessary to have a cone of wood, about eight inches high, placed perpendicularly on an iron pin, which must pass through the pan and box, close to the mill, (see fig. A, plate B). This is called a *gimp peg:* it has four or five heights of holes, about half an inch above each other, the lowest hole being about three inches from the bottom of the cone, and the highest nearly at the top, so that a line from it to the edge of the mill would form a perpendicular, and the next a very acute angle; a stick of a definite length is used, and the stone that is to be cut in facets must be cemented to it.

The following method is the general practice of lapidaries:—The first operation is to rough the stone into shape, viz. to cut it into the form of a spinning top, the larger end to form the table, and the smaller the collet. Then the work* is placed as follows: first make the table (*a*, plate B), by placing the largest side of the stone flat on the mill; when that is done, cement the collet side to the stick, and make the *bizil* (*b*), and setting edge (*c*); then the position of the stone must be changed, by melting the cement, and placing it in the opposite direction, that is, by cementing the table side to the stick. The ribs (*e*) and the collet (*f*) must next be formed; after which the steps (*d*), or whatever work is intended. Supposing it should be required to cut steps, it is performed by placing the end

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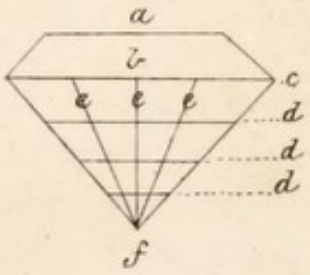
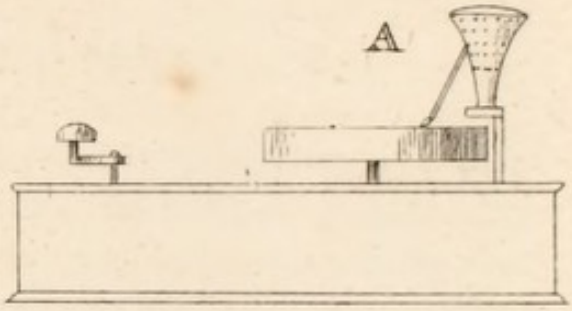
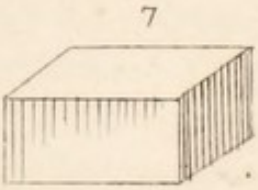
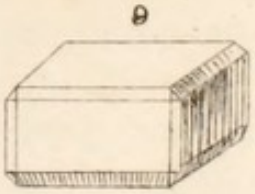
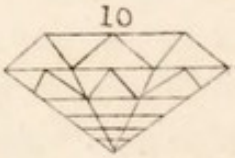
* See Description of Plate B. p. xii.

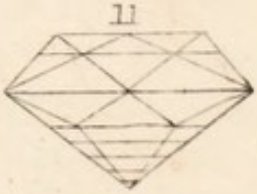


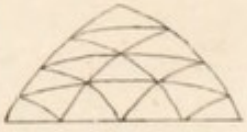


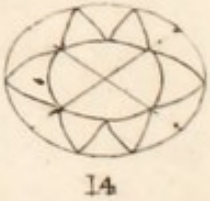












J. Mawe, 149, Strand.

of the stick in the uppermost hole but one in the *gimp-peg*, (see A, plate B), the stone will then come in contact with the mill close to the collet, care being taken to hold it so that the facets will be made between the ribs. By light pressure, and turning with moderate velocity, a plane will be cut in an instant; then turning the stick, the facets are made in the same manner all round. This completed, the end of the stick is held a hole lower, and a row of steps will be cut above the others, and in like manner until the work is finished. Facets are also cut in various forms, and often split, that is, a rhomb cut so as to form two triangles, makes what are called split facets.

It will be evident to the practitioner, that the stick forms different angles with the gimp-peg, as it is placed higher or lower. In this manner all the courses of the work are cut, up to the setting edge. Thus the operations of the lapidary are performed, but it requires great practice, tact, and attention: however, habit will overcome what appears difficult at first; *and, above all,* two or three visits to a workman would be more serviceable than a volume of description*.

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* The ancient mode of cutting stones was with a quadrant having a moveable index, to which the stone was cemented, and placed at any angle desired. This mode, though mathematically exact, is now discontinued, and the workman depends rather on habit in placing his stick at a proper angle, and on his eye, in forming facets.

LIST MILL.

The mill covered with list is used to give the finishing polish to rounded stones, (tallow drop work), as brooch stones, tops of boxes, cornelian drops, coral drops, &c.

It is useful also in polishing shells, particularly such as have an uneven surface. It is used wet, with putty, (*oxide of tin*). A morsel of sponge tied to a stick will serve to supply the water, and the putty may be applied by a common tin pepper box. First moisten the list, and then sprinkle it with putty, which must not be used too wet: the mill should be turned with a quick motion, and the substance will soon receive the highest polish it is capable of.

THE LEATHER MILL.

The mill covered with leather is calculated to give an extra polish to all substances that have a flat surface; it heightens the lustre of amethysts, crystals, cornelians, and other stones, but is more generally used for substances less hard, as marble, malachite, satin spar, &c. It will also polish every variety of metallic substances.

It is used as the preceding, with putty and water, and should be worked with a considerable degree of velocity.

THE SLITTING MILL.

The dividing of hard substances, which resist the best tempered file, into slices, as thin as required, is not easily

imagined by those who are not acquainted with lapidaries' work.

The slitting mill is formed from a very thin soft iron plate, peculiarly hammered, (planished), to make it stiff and elastic. A larger pan should be provided, with low edges; also some oil, (brick oil is the best, and generally used, from its being thin and most fluid), diamond properly reduced to powder*, a watch glass, an instrument called a Jigger, and a piece of glass, as the bottom of a wine glass; a quill cut as a tooth-pick, and one with the feather remaining, and a saucer to hold oil.

All being ready, place the large pan in its proper position, and then screw the mill on the spindle. Apply a little oil to the edge of the mill, and turn it gently, to ascertain whether it runs true; put two or three drops of oil in the watch glass, to which add about half a grain of the pulverised diamond, mix it with the quill, and put a small portion of it in the score of the jigger†, which apply to the edge of the iron plate, and turn the mill gently; this operation should be repeated two or three times.

The mill being of soft iron, the particles of diamond will set in it, by a slight pressure, and form teeth; it is necessary that the whole edge of the mill should present a surface of diamond.

This done, in order to fix or set the particles of diamond in the iron, apply the piece of glass to the mill, at the same time supplying it with oil from the saucer, with the fea-

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* To be had of the Author.

† The Jigger is a roller of hardened steel or brass, invented by the Author, for applying the diamond powder. But lapidaries generally apply it with their fingers.

ther. If the mill now works rough and coarse, it is certain that a sufficient quantity of the diamond has adhered to it; but if, on the contrary, it works smooth and easy, more diamond must be applied, until it cuts freely.

The mill thus prepared will, under proper management, cut whatever is applied to it; but an assistant is required, who must continually supply it with oil, the resistance being so great. It is not necessary to turn very quick, a moderate velocity is best, from fifty to sixty revolutions in a minute. Large stones are held in the hand during the operation, and small stones should be cemented to sticks. The juvenile practitioner should have several small square blocks of wood of different sizes, so that a stone cemented to one of them may be exactly the height of the edge of the mill, whilst it rests on the pan; it would thus be very easily managed, and without any danger to the fingers of the operator. A moveable lever may easily be contrived, if it should be thought necessary.

When the diamond is worn out, which may be known by its ceasing to cut freely, more must be applied.

The expense of priming the mill ought not to exceed sixpence or nine-pence*.

Some lapidaries, who work without an assistant, apply oil in the following manner, viz. the feather end of a quill being dipped in the oil, is laid upon the edge of the slitter, and the other end is held in the operator's mouth: a little

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* The diamond being the hardest substance known, cuts whatever it is applied to; but the resistance from hard stones is so great, that it requires a copious supply of oil. The iron mill thus prepared, forms a circular saw. Diamonds are generally sawed in two by a fine wire and diamond dust.

practice is required to manage this with facility. Others have a reservoir of oil placed above the mill, which is brought down by a wreath of worsted threads, (capillary attraction), one end of which is placed in the oil, and the other just lightly touching the edge of the slitter.

After the learner has slit a small stone, and I advise him not to commence with one above half an inch in diameter, he will then find but little difficulty in proceeding, and also in arranging all the necessaries for work.

It is a general practice among lapidaries to rub the diamond powder with a little oil on a hard stone, or steel slab, with a muller of the same. It may afterwards be scraped off and put into the watch glass. They conceive that by this method they expend less of the diamond.

Note. Many gentlemen have attempted to slit with adamantine spar, (corundum), but without any good effect, although it may be used in place of emery for soft substances.

COPPER SLITTING MILL.

This mill is not in use amongst lapidaries, but belongs more peculiarly to the mason. It is only used for marble and soft stones, that do not give fire with steel. It is the best for the beginner to work with, before he attempts the iron one, which is more delicate. It is used as follows, viz. when screwed on the spindle, and over the pan containing emery belonging to the lead mill, if the edge of it be supplied with wet emery from the brush, the mill will cut any soft stones applied to it. This mill is extremely useful in slitting specimens of marble, and where oil would spoil the work.

COPPER MILL FOR CUTTING ORIENTAL STONES,

As the SAPPHIRE, RUBY, TOPAZ, and CHRYSOBERYL or ORIENTAL CHRYSOLITE. These stones, being infinitely harder than any other, are generally worked on a peculiar mill.

This mill is formed of beaten copper, or of a compound, containing a portion of silver. It resists the friction of hard stones better than lead, and by it the work is performed in much less time, and with greater facility; the method of using it with emery and water is the same as before described.

ANOTHER MILL, of a similar description, is used for polishing; both require to be hacked before they can be worked*.

THE expense of this apparatus, with a supply of emery, putty, and rotten-stone, will cost from eight to ten guineas, according as it has less or more tools. If made with extra mills, and the wood mills hooped with lead, complete, including the gimp-peg for cutting facets, oil used

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* Lapidaries in general do not make use of mills of this description, but substitute the lead and pewter, which, however, do not perform the work so well or so expeditiously.

for slitting, emery, rottenstone, and putty, it will cost a trifle more.

Note. 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.

☞ Ladies or Gentlemen may receive from the Author any information or explanation required; and Purchasers will be shewn all the various operations.

INDEX.

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