First Lessons; Minerals

1882

FIRST LESSONS

IN

MINERALS.

BOSTON:
PRESS OF ROCKWELL AND CHURCHILL, NO. 39 ARCH STREET.
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INTRODUCTION.

This little pamphlet will, it is hoped, serve as a simple and natural introduction to the study of the mineral kingdom. There are manuals which successfully introduce children to the plants and animals; but an equally simple method has not been presented whereby the pupils in large schools could be made acquainted with the inanimate things around them.

The outline here given furnishes a safe foundation for a more extensive knowledge of minerals, and of the rocks which they form. Beginning with the observation of the characteristic qualities of a few familiar chemical elements (simples), such as gold, iron, carbon, oxygen, etc., children are led to their combination in well-known compounds, such as iron-rust, salt, marble, etc., and are prepared for the statement that about a dozen elements, in varied combinations, constitute the air, the water, and the solid crust of the earth; about a dozen more are common in small quantities.

It will also be possible to build upon this foundation an elementary knowledge of chemistry. It is believed that, if children grasp the chemical relations set forth in this course of lessons, it will be comparatively easy to add other and more complicated ones without confusion.

This plan has the advantage of being simple, clean, and safe. The chief element of success lies in the fact that each child sees with his own eyes, and takes in his own hands, the specimens to be studied. In the simple experiments performed by the teacher, great care should be taken to have everything clearly visible, and to have few articles in use at any one time. The amount of general information that a class will bring to the study of these subjects will vary with age, sex, and opportunity. The teacher should not be in haste *to impart information;* for, in so doing, the opportunities for education are lost. Judicious questions will aid in developing the thinking and reasoning faculties of the pupils.

It is desirable to have a specimen of any common mineral or element in the hands of each pupil at the time the lesson upon it is given. One specimen of a rare mineral, in the hands of the teacher, must suffice, and in a few cases even this will not be possible.

The course here outlined is given in sections, each section furnishing material enough for an hour's lesson with pupils from seven to ten or twelve years of age. It will, in most cases, be quite as well to have half-hour lessons, and thus let the material furnish semi-weekly lessons throughout the school year. The elements and minerals indicated in small type may be taken a second year, when this course may be reviewed and extended with the use of Mr. Crosby's "Guide for Science Teaching on Common Minerals and Rocks."

Whatever information is given to the pupils should be as accurate as the present state of our knowledge will allow. The only experiment in which there is the least danger of accident is the one where hydrogen gas is burned. With reasonable care it should be perfectly safe, as the quantity in the test-tube is small. This can be omitted, of course, if the teacher is so disposed. The idea of danger should not be suggested to the pupils, and each experiment should be tried by the teacher beforehand. The only acid used is hydrochloric, and that in a dilute form; so that, while it will of course attack, to a certain extent, whatever it is spilled upon, it is not at all dangerous.

If a spirit-lamp is used, care must be taken not to upset it while lighted, and not to allow the children to be close to the desk or table on which it stands when burning.

LIST OF APPARATUS REQUIRED.

(1) A small spirit-lamp, if possible, although a good candle can be made to do duty for it. The flame of the candle is smoky, and the glass tubes will need to be wiped after heating. (2) Bits of candle. (3) A blowpipe. (4) A magnet. (5) A small bottle of hydrochloric acid. (6) A fruit-jar, or other quart glass bottle. (7) Three test-tubes, with corks to fit. (8) Two feet of small glass tubing, made of hard glass. (9) Some wooden splints, or lighters. (10) A few inches of copper wire. (11) A piece of tin about two inches square. (12) Iron forceps to hold the piece of tin in the flame. (13) Test paper. Litmus paper is the most convenient, as, though a vegetable color, it is so prepared that it will keep.

A very delicate test paper may be prepared from the common purple cabbage, by dipping filter-paper into a strong decoction (made by putting a leaf or two into hot water), and then drying it. This will have to be prepared shortly before needed for use. In case the lessons are carried at all into the field of chemistry this decoction makes a very good test for acids and alkalies.

BOOKS FOR REFERENCE.

Guides for Science Teaching. No. XII. Common Minerals and Rocks. By William O. Crosby. *Ginn, Heath, & Co., Boston.*

Manual of Mineralogy and Lithology. By James D. Dana. *John Wiley & Sons, New York.*

Metals and their Chief Industrial Applications. By C. Alder Wright.

The New Text-Book of Chemistry. By LeRoy C. Cooley. *Charles Scribner's Sons, New York*

STUDY OF ELEMENTS.

INTRODUCTORY STATEMENTS. — A chemical element is a simple substance. It cannot be made by uniting other substances, nor can anything different from itself be obtained from it. The common metals, for example, gold, lead, and iron, are called chemical elements, because nothing different has ever been obtained from them. There are about seventy of these simple substances known; but thirteen of them make up $\frac{99}{100}$ of the known crust of the earth. Very few of the elements are found pure in the earth. They are united with each other to form *compounds*.

GOLD, SILVER, COPPER. — These are chemical elements. They are also called metals, because they have certain properties, such as metallic lustre (a peculiar bright, glistening surface when cut or polished). They are good conductors of heat and of electricity.

Get statements from the pupils in their own words, and from their own observation, of the following facts: —

Gold	**Silver**	**Copper**
is yellow. soft. very heavy. melted easily. the most precious.	is white. harder than gold. heavy. melted easily.	is reddish. not as heavy as silver. melted at a red heat.

They all occur native and also in ores. They can be flattened with a hammer, cut with a knife, and drawn into wire.

Let the pupils find out the uses of each.

They are all used for money and ornaments. Copper is used for cooking utensils, telegraph-wire, and, when mixed with tin and zinc, for brass, etc.

LEAD, ZINC, TIN.

Three more chemical elements. These are also metals. Ask the pupils how they may know this fact. These are not found in the earth as metals (native), but they must be obtained from compounds, called *ores*. These three metals are very much alike in color. Let the pupils find the following differences by observing small bars of each, of about the size of a lead-pencil: —

Lead is soft. very heavy. "lead color." will bend double. melt easily. can be cut with a knife. falls with a dull, heavy sound.	**Zinc** is harder. bluish white. will break. not melt easily.	**Tin** is white. will bend with difficulty. "cry" when bent. not melt as easily as lead.

Uses to be ascertained by the children.

Lead is used for water-pipes because it is soft and easily worked.

The Latin name for lead is *plumbum;* hence the men who work it are called plumbers.

Zinc is used for the lining of refrigerators, for electrical batteries, and to put under stoves.

Tin is used for tin dishes, and for dishes made of iron with tin coatings. In this case the iron soon rusts through.

The degree of fusibility of these metals may be illustrated by heating the end of the bars, one after the other, before the blow-pipe.

For description of blowpipe, and its uses, see Dana's Manual of Mineralogy and Lithology, pages 82 and 83.

IRON COMPARED WITH COPPER AND LEAD.

Let the pupils describe each one, and tell how the one to be studied differs from the other two, and what it is called.

Iron is not reddish like copper.
soft like lead.
does not bend easily like lead.
melts at an intense white-heat and can then be welded.
is soft like wax at this heat.
can be flattened with a hammer and drawn into wire.
has a ringing sound when dropped.
is attracted by the magnet; no other common metal is. (Show this.)
is obtained from iron ores.

A little native iron is found in meteoric stones (from "shooting stars"), and is called meteoric iron. In Greenland a little native iron has been found in a rock which is supposed to have been brought to the surface by a volcano.

There are three forms of iron in the market, — wrought-iron, steel, and cast-iron.

Wrought-iron	**Steel**	**Cast-iron**
is nearly pure iron. the softest.	is not quite so pure. the hardest.	is not as pure as steel. brittle.
Uses.		
For nails. stove-pipes. rails. bridges.	For tools. rails. springs.	For stoves, etc., where shape rather than strength is needed, because it melts at less heat.

Wrought-iron is used for things requiring strength without hardness or elasticity.

Steel is used for things requiring greater strength with hardness or elasticity.

Iron is the most useful of all the metals. There was little progress in civilization until men discovered how to get iron from its ores.

sulphur in a small glass tube, open at both ends, with a strip of moistened blue litmus paper in the upper end where the gas will pass over it. We can find sulphur in ores by this test.

The gas which is formed when carbon is burned will turn clear lime-water milky. To show this, light a splinter of wood and thrust it into a bottle holding a pint or more. After the splinter has ceased burning pour into the bottle a table-spoonful of lime-water and shake the bottle, taking care not to invert it before the gas has had time to be absorbed.

PREPARATORY TO THE STUDY OF OXYGEN.

Procure a small lump of ice — a solid — melt it, and it becomes a liquid; heat the liquid, it goes off into the air and becomes invisible; what do we call it then? A gas. There are, then, real substances which we do not see or feel, but which exist as gases.

Have at hand two dry test-tubes and some splinters of wood long enough to reach to the bottom of the tubes. Let one test-tube be empty, that is, filled with air only; in the other put a quarter of a teaspoonful of powdered chlorate of potassium.

First plunge a lighted splinter into the first test-tube; have the children notice how quickly the light goes out. Then heat the other test-tube over the spirit-lamp until gas is freely given off; plunge another splinter, which is not burning with a flame, but which has only a glowing spark on the end, into this tube. The children will notice that it bursts into a flame. Heat the tube again, and repeat the experiment until every one has seen clearly the difference between the power of the ordinary air and of this gas — *oxygen* — to make things burn (to sustain combustion).

OXYGEN

Is a non-metal, a chemical element, and exists *as an element* in the air. The air is only one-fifth oxygen; it is diluted with another gas called *nitrogen*, which will put out a flame.

If oxygen made the glowing splinter burst into flame, what is it that makes the coal and wood in the stove burn? What makes the lamps burn? What do we breathe air for?

If convenient, it is well to have a fruit-jar or other bottle full of oxygen gas, and into this plunge a glowing piece of charcoal, as large as an English walnut, which is held by a wire. The brilliant display of burning sparks will impress upon the pupils' minds the facts given.

Lime-water should be poured into the bottle after the burning has ceased, to prove the presence of carbonic acid.

Again, place a lighted candle-end under an inverted fruit-jar.

It soon goes out. Why?

Oxygen is an element. The carbon of the charcoal is an element. When the charcoal burns, the two elements unite to form a compound. When iron nails or tools are left out in damp air what happens? What does the iron take from the air? Then we understand that iron-rust is a compound of iron and oxygen.

Oxygen is everywhere in the air, and unites with every other known element but one (fluorine).

Oxygen is a gas at ordinary temperatures.
the most important element.
found as an element in the air.
one-fifth of the air.
one-half the solid crust of the earth.
eight-ninths of the water.
about four-fifths of the weight of vegetable bodies.
about three-fourths of the weight of animal bodies.

Oxygen causes other substances "to burn," as we say; in other words, the union of oxygen with substances is the cause of all that we call burning in ordinary language.

HYDROGEN.

An element, — a non-metal.

Provide a test-tube with a tightly-fitting cork, which is pierced with a small glass tube, bent at a small angle. The outer end of the glass tube should be narrowed so that the orifice is about the size of a pencil-point Into the test-tube put some pieces of zinc; pour in a teaspoonful of dilute hydrochloric acid; close the mouth of the test-tube with the cork carrying the glass tube; after waiting two or three minutes light the stream of gas which is issuing from the small orifice.

Caution. — If the gas is lighted before the air is all driven out from the test-tube a slight explosion may result.

This gas burns in the air as well as the solid carbon does. Now hold over the flame a clean, dry bottle. (This must be a pint bottle, or larger, in order that it may not become hot too quickly.) A mist or vapor will be seen forming on the bottle. This is water. Whenever this gas burns or unites with oxygen, a compound is formed called water. The name of this gas is hydrogen.

Hydrogen is a gas at ordinary temperatures.
seldom found free in nature.
the lightest substance known.
eleven thousand times lighter than water.
one-ninth of water.
in nearly all vegetable and animal substances.
burns with a bluish flame of great heating power.

REVIEW AND CLASSIFICATION.

ELEMENTS.

Metals.	**Non-Metals.**
Gold.	Sulphur.
Silver.	Carbon.
Copper.	Oxygen.
Lead.	Nitrogen.
Zinc.	Hydrogen.
Tin.	
Iron	

COMPOUNDS.

Two elements united are indicated by the termination *ide.*

Iron	and oxygen	united	form	**Iron oxide.**
Carbon	"	"	"	"	**Carbon oxide.**
Hydrogen	"	"	"	"	**Hydrogen oxide.**

The compound is different from either of the elements which form it. We cannot take the oxygen from water to breathe or to make our fire burn, because it is combined with the hydrogen, and is no longer free. The oxygen of the air is only mixed with nitrogen, and therefore it is free to make our fires burn.

LIMONITE, HEMATITE, MAGNETITE.

Iron and oxygen united. A rusted bar of iron, when rubbed on white paper, gives a yellow streak. One of these specimens, when scratched with a file, gives a yellow powder, which does the same. Then, it is reasonable to conclude that we have in this ore iron-rust, or iron oxide, — iron which has taken oxygen from the air. This iron oxide is not magnetic. [Show this.] Place half-a-dozen fragments as large as a pea in a glass tube, and heat them. Water will be seen to collect on the cold glass, and after a few minutes so much will have been obtained that drops of water can be poured out in the sight of the class. Then we have proved that there is water present in the ore. It is called bog iron ore, and its mineral name is **Limonite,** from a word meaning meadow, because it was formed in wet places. Crush up one of the pieces that has been heated, and try its powder on white paper; the streak will be red, not yellow. Ask the children to find the specimen which has a red streak. This is called **Hematite,** from a word meaning blood, because it is red. This iron ore was, very likely, formed like the Limonite, but has been heated in the earth, and the water driven off. It is exactly like the other, without the water.

Show that neither the Limonite nor the Hematite is magnetic. Heat on charcoal, in the reducing flame of the blowpipe, two or three small fragments of the Limonite. The fragments may be of the size of half a pea. They will soon become magnetic, because some of the oxygen has been taken away by the carbon flame. Heat some fragments of the Hematite in the same way. Now test the other black specimen, and prove that it is magnetic, and yet it is not metallic iron, for it is brittle, which iron is not. It is like the little heated fragments. There is less oxygen than in the other ores. This is called **Magnetite,** or magnetic oxide of iron. These are the three most common ores of iron; and metallic iron is obtained from them by taking away all the oxygen in great furnaces.

Questions. — How is iron protected from the oxygen of the air? How are stoves kept from rusting? [See iron burn in blacksmith's forge].

THREE OXIDES OF IRON.

Limonite, streak yellow.	**Hematite,** streak red.	**Magnetite,** streak black.
not magnetic.	not magnetic.	magnetic.
in latest rocks.	in older rocks.	in oldest rocks.
never in crystals.	seldom in crystals.	crystalline.
metallic iron, 60 per cent.	metallic iron, 70 per cent.	metallic iron, 72.4 per cent.
contains water.		the only strongly magnetic mineral.

The two great natural coloring agents are Limonite and Hematite. Almost all the yellow, brown, and red colors in rocks and soils are due to these.

Bricks are red because of iron in them. Where are the great beds of iron ore?

Ask the pupils to be ready at the next lesson to tell about carbon, — where else it is found besides in coal, and what it is used for.

CARBON AND ITS COMPOUNDS.

We have seen the element **Carbon** as it is found in the earth, graphite, diamond, and coal. We have seen carbon as it is made, charcoal, coke, lamp-black. What do we get charcoal from? Then carbon is in wood and in all plants. Burn a green leaf, see it turn black, or *char* as we call it. Show lamp-black by pressing down a candle flame with a bit of cold porcelain. Show that this hot carbon is what makes the flame bright by comparing it with alcohol flame. The candle contains carbon; all fat contains carbon. There is carbon also in many other things. What do plants produce beside stems and wood? Seeds. Heat flour or corn-meal on a plate of tin over a lamp, see it blacken, partly burn, and leave black shining charcoal. Carbon is in all grains, in the starch. Heat sugar in the same way with the same result. We eat sugar, fat, and starch. Why do we eat them? Why do we burn coal? To get heat. The carbon uniting with the oxygen gives heat. When the gas or candle is burning we get heat as well as light. We do not want the heat, but whenever carbon unites with oxygen it must give heat (electric light is better on this account). Iron united with oxygen gives heat, but it oxidizes so slowly that we do not feel it. All burning things give out heat, and *burning*, as we use the word, is uniting with oxygen. What do we breathe *in*? Air, one-fifth of which is oxygen. What do we breathe *out*? Nitrogen and carbonic-acid gas. Prove this by breathing into lime-water, which becomes milky. Where does the carbon come from? From the sugar, starch (grain), fat, which we eat. This burns, that is, it unites in our bodies with the oxygen which we breathe, and so keeps us warm. We get a little heat beside from exercise, etc.; but this is the way most of the heat of our bodies is obtained. Then we must breathe in oxygen enough to keep the carbon burning. Illustrate by the draught for the stove, blowing the fire, and other things. Why does the splinter go out in the test-tube? Repeat some of the experiments for oxygen. There must be plenty of oxygen. Point out need of ventilation. Effects in a close room. The need of air, and plenty of it, at night. Ask why we are warmer when we are in a well-ventilated room. Oxygen has been called vital air. The carbonic-acid gas is called by the miners "choke-damp." It is a compound, and we cannot take the oxygen which it contains from it. Show 8 or 10 ounces of charcoal which is an estimate, from the result of many experiments, of the amount of carbon which, if burned, would give as much carbonic-acid gas as an average man breathes out in 24 hours. Each ton of coal burned gives about 3½ tons of carbonic-acid gas. What becomes of all this? Will not the oxygen soon be all used up? Where did we find carbon? In plants. Where do they get it? From the air, that is, from the carbonic acid in the air. The green growing plant is able, under the influence of sunlight, to tear apart the carbonic-acid gas, use the carbon, and give back the oxygen free, as an element so that we can breathe it. Plants and animals are mutually helpful.

There are two oxides of carbon; one is seen burning in the blue flame playing over a coal fire. This is carbon monoxide, and has only half as much oxygen in it as the other oxide, carbon dioxide or carbonic-acid gas, which has two atoms of oxygen to one of carbon.

Iron burned in air forms iron oxide, Limonite, Hematite, Magnetite.

Hydrogen burned in air forms hydrogen oxide, water.

Carbon burned in little air forms carbon monoxide (poisonous).

Carbon burned in much air forms carbon dioxide, carbonic-acid gas.

Sulphur burned in air forms sulphur dioxide, sulphurous-acid gas.

Show the test again with blue litmus. The odor of burning matches is caused by this gas. It is used for bleaching.

SOME OTHER OXIDES.

Silver Oxide }
Gold Oxide } rare. These metals stay bright in the air, do not rust.

Copper Oxide found in the earth as { Cuprite, red oxide.
{ Melaconite, black oxide.

These are valuable ores of copper.

Lead Oxide, not common native. Litharge is the artificial lead oxide, and is used in the arts.

Zinc Oxide, the mineral zincite, a valuable ore of zinc.

Tin Oxide, cassiterite, stream tin, the ore from which is obtained the tin of commerce.

Mercury Oxide, artificial, heat alone will drive off the oxygen and leave the metallic, liquid mercury.

Aluminum Oxide is corundum, sapphire, ruby.

Calcium Oxide is quicklime.

Sodium Oxide with water is caustic soda, } used in the arts artificially
Potassium Oxide with water is caustic potash, } prepared, not found native.

SILICON OXIDE, OR QUARTZ, OR SILICA.

Silicon is an element resembling Carbon in many of its properties. It is never found free in the earth, but always united with oxygen; we call this compound silica, or, when it is spoken of as a mineral, we call it quartz. This mineral forms more than one-half the solid crust of the earth, and more than one-half the oxygen on the globe is combined with silicon to form silica.

Quartz.

CHARACTER (properties).	VARIETIES.	USES.
It is very hard.	Common quartz.	Rock crystal used for spectacles.
very light.	Milky "	
insoluble.	Smoky "	For glass when melted with soda or potash.
infusible.	Amethyst.	
transparent.	Chalcedony.	
translucent.	Carnelian.	
a constituent of granite.	Agate.	jewels.
does not break smoothly.	Onyx.	
	Flint (strikes fire).	
	Jasper.	
	Sandstone.	building stone.
	Sand.	
	Opal is silica.	

Here is an opportunity for some bits of history. The famous goblets and crystal cups of the old emperors.

An account of the discovery of glass. The fine glass of Egyptian times.

How flint got into the chalk cliffs.

Silica in stems of plants. In some sponges.

IRON PYRITES, OR PYRITE.

If we call iron and oxygen, united into a compound, iron oxide, what shall we call iron and sulphur when united? Iron sulphide. A name ending in *ide* tells us that two things are united in the compound. We must test this mineral to see what it contains. Put into a glass tube, open at both ends, a few grains of the mineral. Insert a bit of moistened blue litmus paper into the upper end and then heat the mineral, as in the test for sulphur. The pupils will notice the blue paper turning red, and at once decide that the mineral has sulphur in it.

Heat these same fragments on charcoal in the reducing or carbon flame of the blow-pipe, and then bring the magnet near them; if they have been heated long enough the magnet will attract them, and thus prove that there was iron in the mineral. Iron and sulphur united form iron sulphide; commonly called iron pyrites. The mineral name is "pyrite." It is yellow in color; somewhat like gold. It is called "Fools' gold," because so many people have mistaken it for gold. The differences are as follows: —

Pyrite is not as yellow as gold.	**Gold** can be cut with a knife.
harder than gold.	is an element.
brittle.	
not as heavy as gold.	
a compound.	
will strike fire with flint.	
is abundant everywhere.	

Used to make sulphuric acid. It is easier to get iron from the iron oxides than from the sulphide, and as there are abundant ores of the oxide the sulphide is not used.

GALENA, OR GALENITE.

Try the test for sulphur with a few grains of this mineral, proving that it is also a sulphide. The lead can be obtained in a malleable globule by mixing soda with the finely powdered galena, and heating the mixture on charcoal in the reducing flame.

Lead Sulphide is brittle and cannot be cut with a knife.

Lead is malleable and can be cut with a knife.

Galenite is the mineral name for lead sulphide. It will mark paper. It is the most common ore of lead.

SOME OTHER SULPHIDES.

Gold Sulphide. Very rare.

Silver Sulphide. Argentite. Rare, but a rich ore of silver.

Copper Sulphide. Chalcocite. Not very common but a rich ore.

Copper Sulphide mixed with *Iron Sulphide* } Bornite. Chalcopyrite. The common ores of copper.

Zinc Sulphide, Blende, Sphalerite.

Called "Black Jack" by the miners; a very common ore, and an obstacle to the treating of the lead ores with which it occurs.

Tin Sulphide. Rare.

Mercury Sulphide, Cinnabar.

Bright red in color, used for paint as vermilion, found principally in Spain and California.

The sulphides of the other metals do not occur in nature.

SODIUM CHLORIDE, OR HALITE, OR ROCK SALT.

There are many other *ides* beside oxides and sulphides. The next to be studied is a **Chloride,** composed of sodium and chlorine. [From this point the outline is not made as detailed as in the previous lessons, as the chemical knowledge possessed by the teacher will largely influence the character of the instruction.] Heat a bit of the salt in the flame of the spirit-lamp. Notice the yellow color of the flame, — sodium flame. The pupils will probably taste the salt without asking. The mineral name is **Halite.** It is found in beds, and mined like any other rock. The solution of it is found in salt lakes, in salt springs, and in the ocean. The beds of rock salt are supposed to be the result of the drying up of portions of the sea. An account of the salt mines in Poland will be interesting. Uses of salt are numerous. A very important one is for the manufacture of sodium carbonate, — soda-ash. This compound is used in large quantities in bleaching, soap-making, glass-making, and many other arts. For process, see Cooley's Chemistry, page 218. Until the discovery of this process all the soda-ash was obtained from the ashes of seaweed.

SOME OTHER CHLORIDES.

Mercury Chloride.	Calomel.
Silver "	Horn silver, a rich ore of silver.
Copper "	Atacamite, found in Chili. Rare.
Calcium Fluoride.	Fluor Spar.
Sodium / *Aluminum* } *Fluoride.*	Cryolite. Found in Greenland. Used in making porcelain-like glass.

If the lessons are carried into chemistry, some artificially prepared chlorides may be taken up, as—

Mercury Dichloride. Corrosive sublimate.

Gold Chloride. Used in photography.

Hydrogen Chloride. Hydrochloric acid (muriatic acid, so called because it was made from sea-salt).

Zinc Chloride. Used for preserving wood.

REVIEW LESSON,

Of which only the outline is here given. Ask the pupils for the names of elements and compounds studied, and write them on the board. The following order is not essential: —

ELEMENTS.		COMPOUNDS.	
Metals.	**Non-Metals.**	— **ides** (*two things united*).	
Gold.	Oxygen.	Iron oxide.	Limonite.
Silver.	Hydrogen.	Iron oxide.	Hematite.
Copper.	Nitrogen.	Iron oxide.	Magnetite.
Lead.	Carbon.	Hydrogen oxide.	Water.
Zinc.	Sulphur.	Carbon dioxide.	Carbonic-acid gas.
Tin.	Silicon.	Sulphur dioxide.	Sulphurous-acid gas.
Iron.	Chlorine.	Silicon oxide.	Quartz, or Silica.
Mercury.	*Phosphorus.	Iron sulphide.	Pyrite.
Aluminum.		Lead sulphide.	Galenite.
Calcium.		Sodium chloride.	Salt, or Halite.
Platinum.			
Sodium.			
Potassium.			
Magnesium.			
*Barium.			

Most of the non-metals unite with the metals. Many of the non-metals unite with each other.

Illustrate this from the table of compounds.

*Compounds containing these elements are mentioned on page 29.

CALCITE, OR CALCIUM CARBONATE (*commonly called Carbonate of Lime*).

Carbonate of Lime is a mineral from which we can get carbon dioxide by heating, and yet we have calcium oxide left. How many elements, then, make up this compound? We call it calcium carbonate, the ending *ate* being used to indicate a union of three things, one of which is oxygen.

Calcium Carbonate (Calcite) forms marble, used for statues and ornaments.
limestone, used for building stone.
chalk.
shell and coral.
fossil shells.
stalactite and stalagmites.

Calcium Carbonate when heated loses carbon dioxide and becomes quick-lime or calcium oxide.

Quick-lime when slaked forms slaked lime, from which lime-water is made, which is used as a medicine as well as in the arts.

Slaked lime mixed with sand is used for mortar, whitewash, and plastering.

Mortar exposed to the air takes up carbon dioxide, and thus the calcium oxide in the mortar becomes calcium carbonate again, and hardens into stone.

This lesson can be made very instructive if the teacher will take pains to draw inferences from the pupils' previous knowledge or observation. It is well to procure a piece of quick-lime and slake it before them.

We wish to know how we are to tell this mineral when we find it, for it occurs in many forms and colors. Put a few fragments of marble into a test-tube, pour on a few drops of hydrochloric acid, a brisk effervescence will follow. Conduct the gas into a tumbler in which is set the end of a candle, lighted, and the candle will go out. This gas is carbonic-acid gas (carbon dioxide), as has been proved before. Test other specimens said to be composed of calcium carbonate by touching them with the end of a glass rod which has been dipped into the hydrochloric acid. The brisk effervescence will show that they give off carbonic-acid gas, as marble does.

An illustration of the formation of caves in limestone regions may be given by breathing into a little dilute lime-water through a glass tube, or by conducting some of the gas from marble into a little lime-water. At first a very milky liquid is seen; after a time the liquid becomes clearer, and if the gas is passed in long enough the liquid will be quite clear. The water when saturated with carbon dioxide dissolves calcium carbonate.

The salution of the limestone rock is effected by this means. Water containing carbon dioxide trickles through crevices and dissolves away the limestone little by little, until, in the course of ages, large cavities are formed.

IRON CARBONATE, OR SIDERITE.

We have now a mineral which looks a little like some kind of limestone. We will heat a little of it on charcoal, or in a closed glass tube; when it is quite black, test it with the magnet. It contains iron. Put other fragments into a test-tube, with some hydrochloric acid, and heat them; a brisk effervescence will take place before the acid boils. There is carbon dioxide. It is, then, iron carbonate, or siderite, composed of iron, carbon, oxygen. We cannot always be sure that a mineral is not a carbonate unless we test it with hot acid; but cold acid will *always* show calcium carbonate.

Siderite is an ore of iron.

Native copper carbonate is Malachite.

Native lead carbonate is Cerussite — the lead ore of Leadville Colorado.

Native sodium carbonate is found on some of the Western plains.

Much sodium carbonate is made from sea salt for washing powders and baking powders. It is called in the market washing soda and cooking soda. In cooking soda there is more carbonic-acid gas, and it is commonly called bicarbonate of soda. It may be well to put some of it in a test-tube and conduct the gas, formed by adding hydrochloric acid, into a tumbler in which is set a lighted candle-end. The perforated cork which was used for the hydrogen experiment may be used for this also.

Common soda water is water which is saturated with carbonic-acid gas, and in the small apparatus often used the gas is obtained from cooking soda by adding to it tartaric acid.

GYPSUM.

If calcium, carbon, and oxygen are called calcium carbonate, calcium, sulphur, and oxygen will be called calcium sulphate. If we drop acid on this mineral it will *not* effervesce, because it has no carbon dioxide in it. It is found in beds like salt, and was probably formed in the same way. It is called **Gypsum.** It is so soft that it can be scratched with the finger-nail. When ground up it is used for a manure, and for whitening walls, and for black-board crayons. When very pure it is called *alabaster.* Heat some fragments in a glass tube, water will be given off; one-fifth its weight is water. When the water is gone it is called plaster of Paris, from the fact that large quarries of gypsum were worked at Montmartre, near Paris. Show the use of plaster of Paris for casts and moulds by mixing up a few spoonfuls with water and allowing it to "set" or harden. The substance of which the cast is taken, the hand for instance, must be oiled to prevent adhesion.

A most instructive lesson in observation of differences can be made by comparing crystallized gypsum or *selenite*, and *mica.* Allow the pupils to find out how to tell them apart.

Mica is darker in color, not chalky when scratched.
will scratch the selenite.
split into thinner plates than selenite.
is very elastic; the thin plates will bend double and then spring back.

SOME OTHER SULPHATES.

Barium Sulphate, Barite, Heavy Spar, is the only other common sulphate found in nature.

Most of the sulphates are soluble in water, and hence are not found as minerals. Some of them are very important in the arts, and may be studied with advantage.

Hydrogen Sulphate. Sulphuric Acid; Oil of Vitriol.

Iron Sulphate. Green Vitriol; Copperas.

This may be made by dissolving a few nails in sulphuric acid. The crystals will form during a night, if the solution is concentrated enough. These crystals, when dried and left in the air, will rust, because the iron in them will take oxygen from the air. Copperas is used in dyeing and as a disinfectant.

Copper Sulphate. Blue Vitriol. Used in electric batteries.

Zinc Sulphate. White Vitriol.

Sodium Sulphate. Glauber Salts.

Magnesium Sulphate. Epsom Salts.

APATITE.

Calcium phosphate, or phosphate of lime.

As we studied only a few *ides*, so we shall study only a few *ates;* but the substance of which our bones are made ought not to be quite passed by. Calcium phosphate is found in all the cereal grains, — wheat, rye, etc., — and these plants soon exhaust the soil. To supply this need there are stored up in the earth beds of the mineral Apatite, which is nearly all calcium phosphate. This mineral is ground up and used as a fertilizer.

SILICATES.

A class of substances which make up the most of the rocks. They are composed of silica (silicon and oxygen) and of one or more of the metallic elements. While one metal is the leading one, there are nearly always small quantities of other metals present. We call these minerals *ates* because three elements predominate, and because we do not know of a better word.

Silica, as we already know, makes up more than half the crust of the earth. It does not always occur as quartz, however; but it is chiefly found in the compounds which we are now to study, — where it is united with metals, to form silicates.

Feldspar. Silicon, oxygen, aluminum, with some potassium.

Mica. Silicon, oxygen, aluminum, a little iron, with some potassium.

Hornblende. Silicon, oxygen, calcium, a little iron, with some aluminum.

Feldspar. Fieldspar, or the common mineral of the fields. Notice the cleavage (it breaks evenly), and the peculiar flash when held up so that the light falls upon it. This flash is due to the perfect planes of cleavage; notice also hardness. Show some other varieties, as Amazon-stone,

Mica. Common Mica, or Muscovite, Muscovy glass. Used for windows in Siberia. Notice the thinness of the plates into which it will split up, its transparency, its great elasticity. Used for stoves, lanterns, etc.

Hornblende. Black or dark green; tough. Asbestus is the only variety used in the arts. This looks like flax, and is made into fire-proof garments and other materials. Used for napkins by the ancients because it could be cleansed by throwing into the fire for a few minutes; also in the temples, for wicks of lamps, which might never go out. The name asbestus means unconsumed. It is now used for lining iron safes, and for protecting steam pipes and boilers.

These three silicates, with quartz, make up the rocks which we call granite, gniess, etc. For further account of these, see Science Guide No. XII., Crosby.

The granite rocks decay and fall into pieces after long ages of exposure to the weather. The hard grains of quartz form sand, and finally sandstone. The feldspar and mica, in decaying, give up the potassium to the soil, and the plants thrive upon it. The white feldspar, after losing the potassium, becomes kaolin clay, which is used for pottery, bricks, etc.

SOME OTHER SILICATES.

Pyroxene, nearly like hornblende, shape of crystals different.

Talc, silicon, oxygen, magnesium. The softest of all minerals, soapy feel, usually greenish in color, lustre pearly, when foliated not elastic.

Used as steatite or soapstone, for fireplaces, stoves, etc.; as fine French chalk, for removing grease-stains from cloth.

Serpentine, silicon, oxygen, magnesium. Not as soft as talc; rich green color; when mixed with limestone makes a fine marble called verd-antique.

Epidote, a peculiar yellowish-green (pistachio-green) silicate.

It has no use in the arts. It does not often form rock masses.

There are many silicates which occur only as crystals scattered through the rocks, and which do not form rock masses. They are often beautiful and always interesting minerals; three only of the most common will be briefly referred to here, — *Garnet*, *Beryl*, *Tourmaline*.

Garnet. Almost always in crystals, common in dodecahedrons. It is known by its crystals and deep red color in the common varieties. When transparent it is called precious garnet and is valued as a gem. It is supposed to have been the carbuncle and hyacinthe of the ancients. Pulverized garnet is sometimes used as a substitute for emery. Common in mica schist and gneiss.

Beryl. In six-sided crystals, hexagonal prisms. Usual color a blue-green; when clear it is aqua-marine. The rich green variety is the emerald. This silicate is harder than quartz.

Tourmaline. A common black mineral in granite rocks; resembles hornblende, but is resinous when broken. It is usually in long crystals of a triangular cross section. The red and green varieties are used as gems. The crystals when rubbed or heated become electric, that is, they attract hairs or woollen fibres.

There are about 700 well-known minerals.
Of these 200 are *ides*.
200 are silicates.
300 are other *ates*, sulphates, etc.

The silicates which form rock masses and one of the carbonates are used for building purposes just as they are quarried and shaped. Man has to go through long processes to obtain most of the metals. The savage races had gold, silver, and copper, but until iron was discovered no hard tools could be made with which to cut rocks and build machines. Thus we see that the use of iron is essential to modern civilization.

There are other metals which we have learned about that would be very useful if we only knew how to get them cheaply enough. Aluminum is an example. It is the most abundant metal in the earth, and for dishes and many other purposes it would be valuable if it could be obtained cheaply.

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