Unit 4 Rocks and minerals

Metals in the earth's crust

Metals play an important role in our lives. Can you name some uses of metals?

We get some metals from the ocean. Can you name an example? *Sodium*

Most of the metals come from the earth's crust. About 25% of the earth's crust consists of metals. Only a few metals, such as silver and gold, exist as free elements in the earth. Most of them exist as compounds in nature.

The individual compounds that make up the rocks are called **minerals**. Rocks from which we obtain metals are called **ores**.

Extracting metals from their ores

Getting a metal from its ore is called extracting the metal.

The table below shows five common metals. They are extracted from different ores.

Metal	Name of ore	Extraction method
Aluminium	Bauxite	*Electrolysis of molten ore*
Copper	Copper pyrite	*Heating alone*
Lead	Galena	*Heating the ore in air and then heating with carbon*
Iron	Haematite	*Heating with carbon*
Mercury	Cinnabar	*Heating alone*

1. Complete this table before the lesson.
2. Aluminium is more abundant in the earth's crust than iron, yet it is more expensive than iron. Suggest a reason for this.

Physical methods

Only metals which exist as free elements can be extracted by physical methods. Why?

Compounds cannot be separated by physical methods. Chemical methods have to be used.

For example, gold and silver can be extracted by this method. Have you heard about the panning for gold?

Heating the ore alone

For example, mercury can be extracted from cinnabar (mercury(II) sulphide) by heating alone.

$$\text{mercury(II) sulphide} + \text{oxygen} \xrightarrow[\text{heat}]{} \text{mercury} + \text{sulphur dioxide}$$

Another example is that if silver exists in the form of oxide, it can also be extracted by heating the oxide alone.

$$\text{silver oxide} \xrightarrow[\text{heat}]{} \text{silver} + \text{oxygen}$$

Heating the ore with carbon

If the metal compound is too stable to be extracted by heating the ore alone, the method of heating with carbon can be used.

For example, iron can be extracted from haematite (iron(III) oxide) by heating with carbon.

iron(III) oxide + carbon $\longrightarrow$ iron + carbon dioxide

Electrolysis of molten ore

If the metal compounds are too stable to be extracted by the above methods, the method of electrolysis of the molten ore has to be used. This method can be used extract all metals. However, it is an expensive method. It would only be used when other methods fail.

For example, sodium, magnesium and aluminium can be extracted by electrolyzing their molten ores.

The **availability** (also the **price**) of metal depends mainly on

1. the abundance of the metal in the earth;
2. the ease of mining its ore and the cost; and
3. the ease of extracting the metal from its ore and the cost.

Investigating calcium carbonate

Limestone is a common rock on earth. They consist mainly of the mineral calcite Limestone caves are interesting geographical features. To understand how limestone caves are formed, we need to study the chemistry of calcium carbonate.

A limestone cave

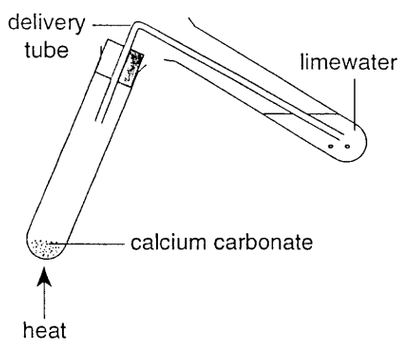
Calcite

Action of heat on calcium carbonate

Limestone (**calcium carbonate**) changes to a white powder called **quicklime** (**calcium oxide**) on heating.

$$\text{calcium carbonate} \xrightarrow{\text{heat}} \text{calcium oxide} + \text{carbon dioxide}$$

The following setup can be used to show that carbon dioxide gas is released when calcium carbonate is being strongly heated. What would be observed in the limewater? *Turns milky.*



When water is added to quicklime (calcium oxide), **slaked lime** (**calcium hydroxide**) is formed.

$$\text{calcium oxide} + \text{water} \longrightarrow \text{calcium hydroxide}$$

Slaked lime is slightly soluble in water. A **saturated solution of slaked lime** is called **limewater**. Limewater is used to test for carbon dioxide gas. Carbon dioxide gas turns limewater milky due to the formation of **insoluble calcium carbonate**.

$$\underset{\text{dioxide}}{\text{carbon}} + \underset{\text{hydroxide}}{\text{calcium}} \longrightarrow \underset{\text{carbonate}}{\text{calcium}} + \text{water}$$

However, when excess carbon dioxide is passed into limewater, the milky solution will become clear again. It is because the **insoluble calcium carbonate** will react with excess carbon dioxide and water to form the **soluble calcium hydrogencarbonate**.

$$\underset{\text{carbonate}}{\text{calcium}} + \underset{\text{dioxide}}{\text{carbon}} + \text{water} \longrightarrow \underset{\text{hydrogencarbonate}}{\text{calcium}}$$

Action of water on calcium carbonate

Calcium carbonate is insoluble in water.

Action of dilute acid on calcium carbonate

When calcium carbonate is put into acid, for example, dilute hydrochloric acid, **effervescence** occurs. [Effervescence means that a large amount of bubbles is given off quickly.]

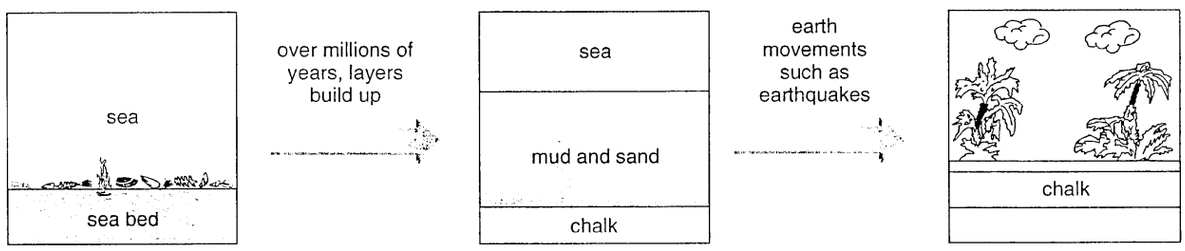
Actually, calcium carbonate will react with dilute hydrochloric acid to form the water soluble calcium chloride. Water and carbon dioxide are also produced at the same time.

$$\underset{\text{carbonate}}{\text{calcium}} + \underset{\text{acid}}{\text{dilute hydrochloric}} \longrightarrow \underset{\text{chloride}}{\text{calcium}} + \text{water} + \underset{\text{dioxide}}{\text{carbon}}$$

Formation of chalk, limestone and marble

Calcium carbonate occurs naturally in three main forms – **chalk**, **limestone** and **marble**. Chalk is the softest among them while marble is the hardest.

The formation of chalk is shown in the diagrams below.



sea animals die and their skeletons or shells sink to the sea bed

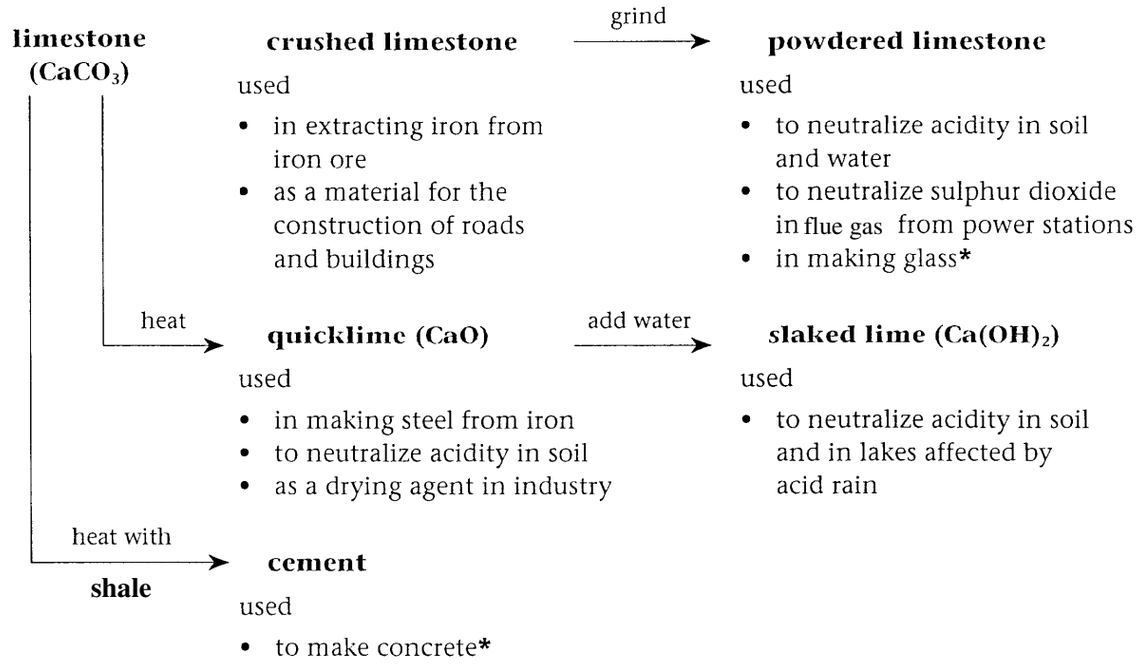
pressure from the top layers changes the bottom layers into chalk

the layer of chalk is lifted to the Earth's surface

Earth movements may also cause the chalk to sink further. Higher pressure and heat will turn the chalk into limestone and then marble. (Refer to the diagrams below.)

chalk limestone marble

Uses of limestone



Formation of limestone caves

Solid rocks can be broken down into smaller pieces and changed into other materials as a result of **weathering**.

The wearing away of surface materials and the movement of products away from where they are formed are called **erosion**.

The major causes of erosion are gravity, running water, waves, ice and wind.

Limestone caves are formed as the result of erosion.

When rain falls, it will react with carbon dioxide in the air to form carbonic acid.

$$\text{water} + \text{carbon dioxide} \longrightarrow \text{carbonic acid}$$

When this dilute carbonic acid falls underground and comes into contact with the limestone deposits, it will react with them to form the water soluble calcium hydrogencarbonate.

$$\text{calcium carbonate} + \text{carbonic acid} \longrightarrow \text{calcium hydrogencarbonate}$$

The underground limestone deposits are gradually dissolved over millions of years, creating underground holes called limestone caves.