Rocks and soil

Introduction

It is by no means necessary to be a geological expert to implement a worthwhile study of rocks and soil at primary school level. Rocks and soil are not difficult to collect, and are a very good vehicle for outdoor activities while at camp or on excursions, collecting and classifying, or making rocks in the classroom.

Students can be fascinated by rocks and soil. A simple rock collection, showing a variety of shapes, sizes, colours and textures, is a good resource. Rocks and soil can be collected during trips to the country, at building sites around the city, or in the back garden.

Mining and metals are very closely related to rocks and soils as a topic. We have included some interesting activities that could be covered under the topics of rocks, soil and mining.

Key concepts of rocks and soil

The activities in this topic are designed to explore the following key concepts:

Early years

- Earth is covered with rocks, soil, water and ice.
- Rocks can vary in shape, texture and mass.
- Rocks can be a single colour or contain many colours.
- Some rocks contain fossils.
- Humans make rocks to help them live more easily.
- Rocks slowly change by wearing away.
- Crumbled rocks form part of soil.
- Some rocks are harder than others.

Middle years

- Rock layers are located under soil, water and ice.
- Natural rocks are made in many different ways.
- Rocks that we find at a particular place may have been made elsewhere.
- Some natural rocks became solid very quickly, while others took a long time to become solid.
- Rocks are made of minerals.

- Rocks can be made of one or more minerals.
- Minerals can form crystals.
- Crystals can have straight edges and flat slides.
- Some rocks act as magnets.
- Some rocks are conductors of electricity.
- Soils are produced, in part, from the weathering of rocks.
- Soil can be made up of organic (animal and plant) material, inorganic (grains of rock) components, and water.
- Eroded rock material can be deposited in layers to form sedimentary rocks, such as sandstone, limestone and mudstone.
- Igneous rocks, such as pumice and granite, are formed by magma from inside the Earth rising to the surface and cooling.
- Sedimentary and igneous rocks that are subject to heat and pressure form metamorphic rocks, such as marble, quartzite and slate.
- Minerals are constituents of rocks.
- Some minerals (e.g. gold and diamonds) are highly valued by humans.
- The ornamental use of rocks is determined by their colour, mineral content and markings.
- The varying hardness of rock is an important factor in its usage.
- Humans' knowledge of rock formation helps them to find oil and precious stones (e.g. gold, opal, emeralds, etcetera).

Students' alternative conceptions of rocks and soil

Research into students' ideas about this topic has identified the following non-scientific ideas:

- Pebbles and stones are thought of as 'not rocks'.
- All rocks are thought to be hard.
- Rocks stay the same for ever.
- Rocks must be heavy.
- Soil must have always been in its present form.
- Earth is molten, except for its crust.

The rock cycle

Earth's crust is not stationary as one may think; it is constantly moving. The dynamic nature of Earth's crust means that as new rock is formed at one location it deteriorates at other locations; this is the rock cycle. There is an enormous variety of rocks and their constituent minerals present in Earth's crust, but all rock varieties are classified as one of three basic types: igneous, sedimentary and metamorphic. These basic types of rock relate to the manner in which the rocks were formed. The mining of rocks and minerals from Earth's crust has provided humankind with many benefits, including building materials, fossil fuels (oil, coal and gas), and precious metals and minerals for cosmetic and industrial uses.

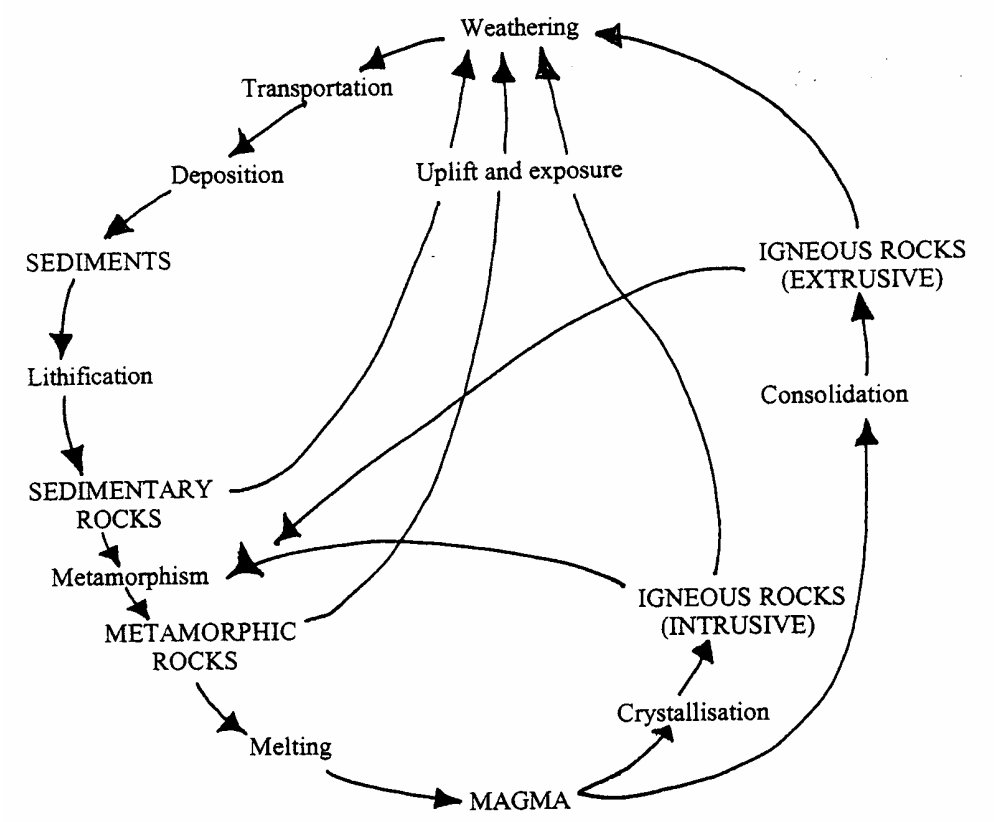
A rock is an aggregate of minerals. Minerals are naturally occurring, inorganic, crystalline solids that have definite physical and chemical properties. There are two exceptions to this definition: these are naturally occurring glass, called obsidian, and sedimentary rock coal. More than 3500 minerals have been identified and described but only about a dozen make up the bulk of the rocks in Earth's crust.

All rocks in Earth's crust, with the exception of meteorites, were formed from magma (molten rock material) pushed up from the mantle (interior layer of Earth). While the original rock material comes from the mantle, geologists (scientists who study rocks) distinguish three distinct processes of rock formation: every rock is then generally classified according to its mode of formation. The three major groups of rocks are igneous, sedimentary and metamorphic.

The interrelationships between Earth's internal and exterior processes of rock formation and disintegration are described by the rock cycle. The rock cycle is shown in the figure below. The rock cycle:

- relates the three rock types to each other
- shows surface processes such as weathering, transportation and deposition
- shows internal processes such as magma generation and metamorphism.

FIGURE:
THE ROCK CYCLE



Movements in Earth's crust are the mechanisms responsible for recycling rock materials; they therefore drive the rock cycle.

Igneous rocks

Igneous rocks are formed through the crystallisation of magma as it cools either in the mantle or on the surface after a volcanic eruption. The components of rock are minerals and each mineral forms, or crystallises, under a certain temperature and pressure. The variation in pressures and temperatures is great when one extends from the mantle to the surface, so it is not surprising that a huge variety of minerals exist. Crystallisation is the process by which the mineral particles form tight bonds in a well-defined three-dimensional shape.

ACTIVITY: CRYSTAL SHAPES

Look at the crystal shapes of sugar and salt under a magnifying glass. The size of the crystal is determined by the time that it takes to cool. If cooled slowly, the crystal shapes are large.

As magma cools, minerals crystallise, and the resulting rock is characterised by interlocking mineral crystalline grains. Magma that cools beneath Earth's surface produces intrusive igneous rocks (also called plutonic rocks), while magma that cools at Earth's surface produces extrusive igneous rocks (also called volcanic rocks) (refer to Figure 1). Igneous rocks that cool slowly have a coarse-grained texture characterised by large mineral crystals, whereas rocks that cool quickly are fine grained and have small mineral crystals. Generally, intrusive rocks are coarse grained, whereas extrusive rocks are fine grained.

Common volcanic rocks include tuff, rhyolite, andesite and basalt. Common plutonic rocks include granite, diorite and gabbro.

Weathering, erosion and deposition

Weathering is the physical breakdown (disintegration) and/or chemical alteration (decomposition) of rocks on Earth's surface. These changes are caused by the weather—by air and water. There are two types of weathering: mechanical and chemical; usually taking place at the same time.

Mechanical weathering is the breaking up of rocks and mineral into smaller pieces. This can occur in various ways:

- trees and other plants send down roots into cracks in rocks, wedging them apart
- water and wind erode the surface of rocks
- temperature changes in the environment expand and contract rock to create cracks
- liquid water gets into cracks and as it freezes it expands, and wedges apart rocks (water expands about nine per cent when it freezes)
- animals burrow and help break up the rock.

Chemical weathering includes all the chemical changes that take place when air and water attack the rocks. Chemicals in the water break down the rocks. As mechanical weathering breaks apart the rocks, there is more surface area on the rocks for chemical weathering to occur.

Weathering yields the raw materials for both soils and sedimentary rocks. The small particles of rock are called 'sediment', which is generally transported to

another site where it accumulates. The method of transportation varies. Glaciers can move any sized particle, whereas wind transports only sand-sized and smaller sediment. Waves and marine currents also transport sediments, but by far the most common method of transportation is by running water (rivers and streams). Any geographical area in which sediment is deposited is a depositional environment.

Soils are sediments that combine with humus. Humus gives many soils their dark colour and is derived from bacterial decay of organic matter.

Sedimentary rocks

Following the weathering of rocks, the sediment formed is transported and deposited at a depositional environment. These deposits may become compacted and/or cemented and thereby converted into sedimentary rock. The process by which sediment is transformed into rock is called ‘lithification’.

About ninety-five per cent of Earth’s crust is composed of igneous and metamorphic rocks, but sedimentary rocks are most common at or near the surface. Approximately seventy-five per cent of the surfaces exposed on continents consist of sediments or sedimentary rocks.

Sedimentary rocks are generally classified as detrital or chemical. Detrital sedimentary rocks consist of solid particles of pre-existing rocks. The fragments might be tiny or large. The following table gives the name of the original sediment, the lithification process and the rock type produced.

TABLE: SEDIMENT TO ROCK

Sediment	**Lithification process**	**Rock**
Gravel (greater than 2 mm)	Compaction/ cementation	Conglomerate (rounded particles) Breccia (angled particles)
Sand (2 mm to 0.06 mm)	Compaction/ cementation	Sandstone
Silt (0.06 mm to 0.004 mm)	Compaction/ cementation	Siltstone
Clay (less than 0.004 mm)	Compaction	Shale

Chemical sedimentary rocks originate from the weathering process where rock material is dissolved into water and transported to lakes and oceans. Here chemical processes take place that result in the accumulation of minerals. Organic material may also be involved in the chemical processes. The rocks produced are called biochemical sedimentary rocks. For example, coal is composed of the compressed, altered remains of organisms, mainly plants. Another example is a type of limestone called coquina that consists entirely of broken seashells cemented by calcium carbonate.

Areas on Earth’s surface where sedimentary rock is found are characterised by distinctive layers and the presence of fossils. Rivers transport sediment from

one location to another deposit in layers. Over many years different layers build up. Sometimes dead animals and plants get immersed into the sediment layers. Therefore, following lithification, the sedimentary rock produced is in layers that quite often contain the remains of ancient organisms, called fossils.

Metamorphic rocks

Metamorphic rocks result from the transformation of other rocks by metamorphic processes that occur below Earth's surface. Through heat and pressure, igneous and sedimentary rocks are transformed into metamorphic rocks. In the metamorphic process the change in the rock may be minor and the features of the parent rock are still recognisable. The change may also be major and result in the formation of new minerals and/or a change in texture of the rock. In this situation any features of the parent rock may be unrecognisable.

Activities

Properties of rocks

ACTIVITY: CLASSIFICATION

Key idea: Natural rocks have a range of properties and appearances.

You will need:

- **a collection of rock samples.**

This activity is best done in pairs or small groups.

Choose one of the rock samples supplied and write a description of it. Your partner should do the same. Then exchange descriptions and see if you can each identify the sample the other one described.

Group a number of rock samples according to one characteristic and see if your partner can identify the characteristics used.

One member of the group chooses a rock sample from a group of rock samples. The other members then ask questions which enable them to identify the sample chosen. The person who has chosen the sample should only answer 'yes' or 'no' to the questions. How many questions are required to find the sample chosen?

ACTIVITY: TESTING ROCKS

Key idea: Natural rocks have a range of properties and appearances.

You will need:

- **a collection of rock samples**
- **measuring scales**
- **sketching paper and a pencil**
- **a hammer**
- **a magnifying glass**
- **a copper coin**
- **a pin**
- **a penknife**
- **a drop of vinegar**

- **some water**
- **a piece of metal**
- **a bathroom tile.**

This activity is best done individually. Choose a rock from the collection and try the following tests on it:

- **Is your rock light or heavy? Estimate its weight, then check your answer.**
- **Sketch your rock.**
- **Describe your rock. Is it single or multi-coloured, bright or dull? Has it got layers? Does it look like it has small rocks stuck together?**
- **Rub the rock with your finger. Does any rub off?**
- **Hammer off a portion. Can you crush it? Look at the particles with your eye or a hand-lens. Are the particles fine or coarse?**
- **Are the particles single or multi-coloured? What is the colour of the inside remaining rock?**
- **Try a hardness test with a fingernail, copper coin, pin, and penknife.**
- **Are there layers to be seen?**
- **Does a drop of vinegar (acid) cause bubbles? If so, the rock contains lime.**
- **Does it absorb water? Easily?**
- **Knock a piece of metal against your rock. What sort of sound is produced? High pitch, low pitch or metallic?**
- **What is the colour of its streak on the back of a bathroom tile?**

Explanatory note: The following tables, when read from left to right, represent rock-type identification keys. The first table gives a clue to the rock type in general, whereas the following tables provide extra information to determine the name of the rock.

TABLE: WHAT ROCK TYPE IS IT?

Rock types				
Texture	Grains visible to the naked eye	Interlocking grains	No alignment of grains	Igneous
			Some grains aligned	Metamorphic
			Bubbles with acid	Metamorphic
		Grains do not interlock	Separate grains held together by finer material	Sedimentary
	Grains not obvious	Can be scratched with a knife	Sedimentary	Sedimentary
			Bubbles with acid—may have fossils	Sedimentary
			Fossils present—no acid reaction	Sedimentary
		Cannot be scratched with a knife	Can be split into thin rock sheets	Metamorphic
			Cannot be split into thin rock sheets	Igneous

TABLE: WHAT IS THE NAME OF THIS IGNEOUS ROCK?

Igneous rocks key					
Texture	Visible crystals	Light coloured	Large crystals/speckled		Granite
			Small crystals/layered		Rhyolite
		Dark coloured	Large crystals	Black	Grabbo
				Green	Peridotite
			Small crystals	Black/grey	Basalt
	No visible crystals	Black/glassy			Obsidian
		White/porous (floats on water)			Pumice
		Red/black porous			Scoria
	Rock and mineral fragments	Layered			Tuff

TABLE: WHAT IS THE NAME OF THIS SEDIMENTARY ROCK?

Sedimentary rocks key					
Texture	Visible fragments	Rock and mineral fragments	Over 2 mm size	Angular fragments	Breccia
				Round fragments	Conglomerate
			Sand-size 0.6 mm to 2 mm		Sandstone
		Plant and animal fragments	Plant fragments	Black or brown	Coal
			Animal fragments	Shell or Coral	Limestone
	No visible particles. Very fine	Reacts with acid			Limestone
		No reaction with acid		Breaks into layers	Shale
				Uniform structure, not layered	Siltstone Mudstone

TABLE: WHAT IS THE NAME OF THIS METAMORPHIC ROCK?

Metamorphic rocks key				
Appearance	Shows layers, smooth parallel surfaces	Texture very fine. Grains not visible to naked eye	Dark, dull surfaces	Slate
			Light, shiny surfaces	Phyllite
		Texture coarser. Grains visible to naked eye	Mica grains and layers visible	Schist
			Banded appearance	Gneiss
	No layers, no smooth parallel rock surfaces	Not scratched with knife	Reacts with acid	Marble
			Dark in colour	Homfels
			Light in colour or quartz grains visible	Quartzite
		Scratched with knife. Reacts with acid		Marble

ACTIVITY: BREAKING UP ROCKS

Key idea: Sedimentary rocks are made through crushing soil or sediment.

You will need:

- **a collection of rocks including sandstone, mudstone, limestone and granite**
- **some samples of soil types**
- **a hammer.**

Crush some sandstone, some mudstone and some limestone. Examine the materials formed. In what ways are they similar? In what ways are they different?

Compare your crushed samples with soil. In what ways are they different?

Examine a small piece of coarse-grained granite. How many different minerals are present? Estimate the relative amounts of the three main components.

Crush the granite with a hammer to pieces about rice-grain size, and separate into the different mineral components (quartz, feldspar and a little mica).

How close was your initial estimate?

Explanatory note: The sedimentary rocks, when broken up, reverse the process by which they were formed. Sandstone and mudstone were originally small rock particles that were crushed, whereas the limestone was tiny rock particles that underwent chemical processes in addition to being crushed. The coarse-grained granite was formed by slowly cooling magma to form an igneous rock.

ACTIVITY: ROCKS THAT FLOAT

Key idea: Some rocks are light and may float.

You will need:

- **samples of pumice, en-tout-cas, basalt, coal, coke, toffee and honeycomb**
- **a bowl of water.**

Examine a piece of pumice (pumice is aerated rock foam that has been rapidly cooled). Try floating it in water.

Can you find other rocks with air bubbles? Do particles of en-tout-cas (from a tennis court) float?

Describe the common difference between toffee/honeycomb, coal/coke and basalt/pumice.

Explanatory note: These types of igneous rocks were formed by volcanic eruptions that have cooled very quickly in the air. In cooling, bubbles of air were trapped.

Rock and soil formation

ACTIVITY: SOIL FACTORY

Key ideas: Crumbled rocks form part of soil. Weathering of rocks creates soil.

You will need:

- **soil from different parts of the garden**
- **water in a container with a lid**

- **crushed sedimentary rock**
- **compost**
- **a bottle to mix the water and soil in.**

Mix the soil with plenty of water, shake and let settle. Note the sand/silt/clay/humus composition. Which particles settle out first?

Can you make some soil to match, using crushed sedimentary rock and compost?

ACTIVITY: SEDIMENTS IN LAKE AND RIVER WATER

Teaching note: This activity, and *Breaking up rocks* and *Soil factory*, gives the students insight into the processes by which sedimentary rocks are formed.

Key idea: Sedimentary rocks are formed from crushing existing rock particles.

You will need:

- **a bottle of water collected from a nearby lake or river**
- **a magnifying glass or microscope.**

Ideally, water should be collected from moving water near the shore of the lake or from the current in the river. Don't stir up the bottom sediment when collecting the samples.

Let the sample of water stand. How long does it take for the sediment to settle and the water to clear? Is there any scum or pollution collected on top of the water?

If possible collect water from a stream after it has rained and collect water when there has been a dry spell. Which samples had more sediment? Why?
Pour off most of the water, and let the rest evaporate. Study the sediment under a magnifying glass or microscope. What do you see?

ACTIVITY: ROCK FACTORY

Teaching note: The classification keys outlined in the *Testing rocks* activity provide a means of classifying rocks. Determine whether the artificial rocks match the descriptions in these classification keys.

Key idea: Rocks are made in different ways, both by nature and by humans.

You will need:

- **a collection of sedimentary, metamorphic and igneous rocks**
- **water**
- **plastic**
- **crushed sandstone**
- **clay**
- **sand**
- **cement.**

Survey the classroom, the building and the grounds for a list of material manufactured by humans from mineral/metal origins and now used in construction. Include the gardens, nature strip and road in your list.

Classify the artificial 'rocks' as sedimentary, metamorphic, conglomerate, etcetera.

Make a sedimentary rock, using crushed sandstone and water.

Investigate what works as binding (plaster? clay?).

Make some concrete blocks (conglomerate) using screenings, and different proportions of sand and cement (e.g. 1:2, 2:1, 3:1).

Devise a test to determine the strongest concrete. Compare your samples with samples of commercial concrete. Make bricks using clay (metamorphic). Try adding various materials which could affect the strength, for example, straw.

ACTIVITY: FOSSILS

Key idea: Some rocks contain fossils.

You will need:

- **limestone rocks**
- **a hammer**
- **a leaf**
- **a petri dish**
- **petroleum jelly**
- **plaster of Paris.**

Break up some limestone with a hammer. You should be able to find some fossils to investigate.

Make a fossil using the following steps:

- **choose a leaf or flat object**
- **grease it and a petri dish with petroleum jelly**
- **cover with plaster of Paris and allow to set.**

ACTIVITY: MANIPULATING MUD—SCIENTIFICALLY

Key idea: There are different types of soil.

You will need:

- **samples of different soils**
- **a teaspoon**
- **water.**

Place a teaspoon of soil in the palm of your hand. Add water drop by drop until it is thoroughly wet but there is no excess water on your hand.

Record what happens when you try to:

- **use your finger to press the soil flat on your palm**
- **roll it into a long thin ‘worm’**
- **mould it into a tiny bowl**
- **make it into a cube.**

Explanatory note: Soil scientists operating in field locations describe soils as ‘sands’, ‘loams’ or ‘clays’ according to whether they fall apart (sand), hold together in blocks but do not roll into a thin ‘worm’ (loam), or roll out well to a thin ‘worm’ (clay), when moistened and then manipulated as you have done.

ACTIVITY: CONCEPT MAP

Key idea: Rocks are formed through different processes.

You will need:

- **poster paper**
- **a list of ideas related to rocks and soil.**

Construct a concept map on poster paper to link the following ideas:

- **mineral**
- **soil**
- **stone**
- **bedrock**
- **bricks**
- **water**
- **volcano**
- **crystal**
- **sand**
- **sedimentary rock**
- **concrete**
- **metamorphic rock**
- **granite**
- **igneous rock**
- **erosion**
- **quartz**
- **layering.**

Properties of rocks, metals and mining

ACTIVITY: FEELY BOX

Key idea: Metals are minerals that make up rocks.

You will need:

- **a 'feely' box that contains various metals (iron, lead, zinc, brass and aluminium), wood and other non-metallic objects.**

Feel the objects in the feely box. Which are metal? What properties are you using to decide?

Using the objects in the feely box, distinguish between wood, lead, zinc, brass and aluminium.

All but one of the metal objects in the feely box are made of the same metal. Which is the odd one out?

ACTIVITY: TESTING FOR ELECTRICAL CONDUCTION

Key idea: Metals are good electrical conductors.

You will need:

- **a battery**
- **a light bulb**

- **connecting wires**
- **rods made of different metallic and non-metallic materials.**

Use the battery, bulb and connecting wires to check how well the rods provided conduct electric current. That is, the brighter the bulb, the better the conductor.

What appliances around the home make use of the conduction of metals?

ACTIVITY: HOW HARD IS IT?

Key idea: Metals have different hardnesses.

You will need:

- **a collection of different metal surfaces**
- **a ball bearing.**

Compare the hardness of various metals by dropping a ball bearing onto the surface and measuring the height of bounce. The balls will bounce higher from harder surfaces.

ACTIVITY: CONDUCTION OF HEAT

Teaching note: A simple test of electrical conductivity can decide whether an object is metallic.

Key idea: Metals are good conductors of heat.

You will need:

- **a candle**
- **a metal rod.**

Use the candle to place drops of wax along the length of a metal rod. Now place the rod horizontally. Light the candle and heat up one end of the metal rod—take a note of the time it takes each drop of wax along the length of the rod to melt.

Does the heat travel at a steady speed along the length of the rod? Do all metals conduct heat equally well?

In how many ways can you prevent a drop of wax melting at one end of an aluminium rod when the other end is heated?

Can you think of ways in which the property of heat conduction is useful?

ACTIVITY: WHAT IS IT MADE FROM?

Key idea: Metals have a range of properties.

You will need:

- **a collection of objects that are metallic or have some metallic components (a variety of metals).**

For each object, determine whether it is metallic, or contains some metallic components.

What criteria are you using in your determination? Are you able to name the type of metal found?