ROCKS AND SOILS

Science background for teachers

VOCABULARY

Names of different rocks and soils; slate, marble, chalk, granite, sand, sandstone, clay, sedimentary, igneous, metamorphic (for older pupils)

Words to describe different types of rock; rock, stone, boulder, cobble, pebble, gravel, sand, clay, texture, rough, smooth, hard, soft, permeable, impermeable, porous, non-porous, porosity, absorbent

Names of physical processes; weathering, erosion

Note the treatment given here is more detailed than usual to aid teachers understanding although some simplification is necessary to prevent over complication.

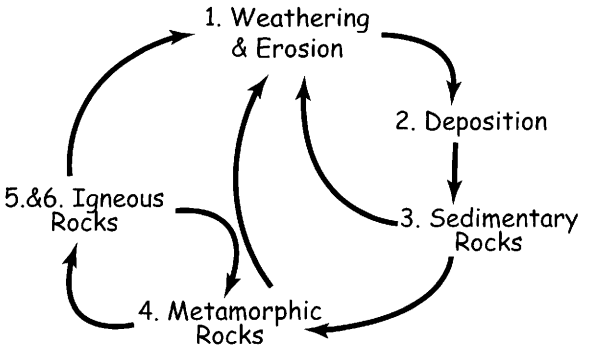
Deep within the earth, hot, molten material called magma is formed. At times, this is forced out onto the Earth's surface when volcanoes erupt, where it cools quickly. Sometimes it is forced into the surrounding rock underground, where it cools slowly. Rocks formed in this way are called **igneous** after 'ignis,' the Latin word for fire. As molten magma cools slowly, minerals within it separate out as crystals, and the slower it cools, the larger the crystals grow. **Granite** is an example of this. Faster cooling magma from volcanoes forms rocks with smaller crystals, such as **basalt.** Both types are hard rocks often used in building. Also, frothy, gas-filled lava from a volcano can cool very quickly to form a very light rock, called pumice. The formation of the two other rock types, sedimentary and metamorphic, can be described in terms of what happens to these igneous rocks.

As pieces of rock are broken off into small particles by the action of weathering eg the freezing and thawing of water in cracks, they are transported by water or wind and finally deposited in layers in the sea as sediment. Physical changes may then take place, such as compression by the weight of later deposits. Chemical changes may also take place such as cementation, when water from the ground seeps through sand, depositing minerals between the grains and forming a natural cement. The cemented particles become **sedimentary** rock such as **sandstone.** Sedimentary rocks which mostly consist of particles larger than 2 mm, are called **conglomerates** if the particles have rounded shapes, and **breccias** if they are sharp and pointed. Other sedimentary rocks may also be made up of **calcium carbonate,** which is the main constituent of the shells of marine animals. When they die, their soft parts decay leaving the shells which eventually form limestone. Chalk is one important variety of **limestone.** Sedimentary rocks may also be formed from plant remains as **coal.** Sedimentary rocks may be softer and easier to cut than igneous rocks but also more easily eroded and affected by weathering.

Sedimentary rocks may be further changed when movement in the Earth's crust compresses them or pushes them deeper into the crust where they are affected by heat and/or pressure. These rocks are called **metamorphic,** from the Greek word for 'change'. **Shale** (fine silt and mud) changes to **slate,** limestone (mostly tiny animals) to **marble,** sandstone to **quartzite** and coal to **coke.**

The whole process can be summarised in the Rock Cycle (see diagram overpage).

The Rock Cycle



1. Weathering and Erosion

WEATHERING attacks rocks in many ways. Examples include acid rain, freeze-thaw, and plant roots. EROSION involves the transport and further breakdown of the weathered rock material by wind, ice, rivers and the sea.

2. Deposition

DEPOSITION of eroded mud, sand and pebbles often takes place in lowland areas. Most of this SEDIMENT is eventually deposited in the sea.

3. Sedimentary Rocks

As layers of sediment build up the lower ones become compacted under their weight and water is squeezed out. In time minerals dissolved in the water may be precipitated between the grains cementing them together, forming SEDIMENTARY ROCKS. Pebbles become CONGLOMERATE, sand becomes SANDSTONE, mud becomes MUDSTONE and shells become LIMESTONE.

(Over millions of years forces in the Earth's crust affect the sedimentary rocks. They may be squeezed during the collision of continental plates to form folds and be pushed above sea level where they may be attacked by weathering and erosion.)

4. Metamorphic Rocks

During plate collision rocks of any kind may be pushed to great depths where the pressures and temperatures are high enough to change them. The original layering and fossils are usually destroyed during recrystallisation but the rocks do NOT melt. Examples of changed or METAMORPHIC ROCKS include MARBLE (from limestone), SLATE (from mudstone) and QUARTZITE (from sandstone).

(After millions of years of uplift and erosion of the overlying rocks these metamorphic rocks may themselves be exposed at the Earth's surface and be attacked by weathering and erosion.)

5. Deep Igneous Rocks

At very high temperatures some minerals in the metamorphic rocks begin to melt. This molten rock, called MAGMA, may rise in the crust, then cool to form IGNEOUS ROCKS. Some cools slowly at depth, forming rocks with large crystals, such as GRANITE.

(After millions of years of uplift and erosion granite may be exposed at the Earth's surface and be attacked by weathering and erosion.)

6. Volcanic Igneous Rocks

Some magma may reach the surface of the crust and erupt as LAVA from VOLCANOES. BASALT is a typical lava and since it cools quickly it is made of small crystals. Frothy lava forms PUMICE and explosive volcanoes produce ASH. Volcanoes are built up from many layers of lava, ash and pumice. They are soon attacked by weather and erosion.

Rocks are made up of minerals, which may exist in many different forms. The crystalline forms can sometimes be cut and polished, for example the form of **carbon** known as **diamond.** Sometimes the minerals contain useful amounts of metals and are known as ores. Some minerals are changed during weathering and form other materials, eg the minerals in **granite** break down very slowly to form **clay, sand** and the oxides of **aluminium** and **iron.**

Many materials from the earth are used for building.

Clay has been used for centuries as a building material. On its own it is not very strong, but strong and cheap materials can be made from clay by heating it and mixing with other materials.

Bricks are made from clay heated to a very high temperature.

Cement is clay and limestone rock heated to a high temperature.

Concrete is cement, sand, stones and water mixed together.

Fredrich Mohs used rock minerals as 'scratchers', minerals that would either mark other minerals or would be marked by scratching. Using this test he then scaled rocks according to their hardness. So according to his scale, talc is the softest and will not scratch any other, diamond is the hardest, will scratch all the others and not be marked by any other.

Internet

Mohs Hardness Scale

(1) Talc	(6) Feldspar
(2) Gypsum	(7) Quartz
(3) Calcite	(8) Topaz
(4) Fluorspar	(9) Corundum
(5) Apatite	(10) Diamond

The fragments in sedimentary rocks are classified by size using familiar names.

Name	Diameter
Boulder	greater than 256 mm
Cobble	64-256 mm
Pebble	4-64 mm
Gravel	2-4 mm
Sand	1/16-2 mm
Silt	1/256-1/16 mm
Clay or mud	less than 1/256 mm

Soil is made up of dead plant and animal material mixed together with mineral particles formed by the weathering of rock. Micro-organisms in the soil cause the decay of the plant and animal materials which releases acids and nutrients into the soil. Soil formation begins as a result of the action of colonisation on bare rock of lichens, mosses and then small plants and animals, a slow process. Soil formation is faster when rock sediments are colonised, dead plant and animal material decays and mixes with mineral particles from the weathered rock.

Weathering is the process taking place when gases and water in the atmosphere combine with surface water and solar radiation to break up surface rocks. There are three main types of weathering:

- **Mechanical weathering** (physical) caused by, for example, rocks heating up, expanding during the day and rapidly cooling at night.
- **Chemical weathering,** the breakdown of rocks by chemical reaction. An example is the breaking down of limestone with rainwater.
- **Biological weathering** caused by plant roots stressing the rocks as they grow.

Erosion is frequently confused with weathering and is the breaking down of rocks by movement of rivers, ice, sea or wind.

Identification of Rocks

Rocks can often be identified using keys. Four rather complex examples are given overleaf for teachers to modify depending on the abilities of their children. A simple version is shown on page 46.

SKILLS

- Careful observation with a magnifying glass.
- Classifying according to given criteria.
- Carrying out repeated classification tests fairly.
- Recording results in chart form.
- Using a simple key.

Start here

Made from grains which may include fragments of fossils stuck (cemented) together → YES → This is SEDIMENTARY go to KEY 2

NO

Made from crystals locked together

NO

YES

Light and dark coloured crystals mixed together and with no obvious bands → YES → This is IGNEOUS go to KEY 3

NO

Crystals are separated into bands → YES → This is METAMORPHIC go to KEY 4

NO

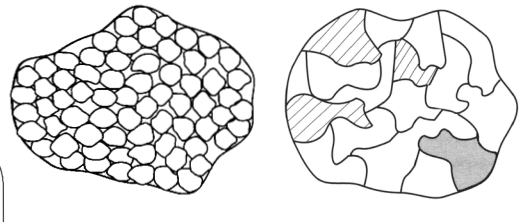
Crystals are white and sugary → YES

NO

START AGAIN!

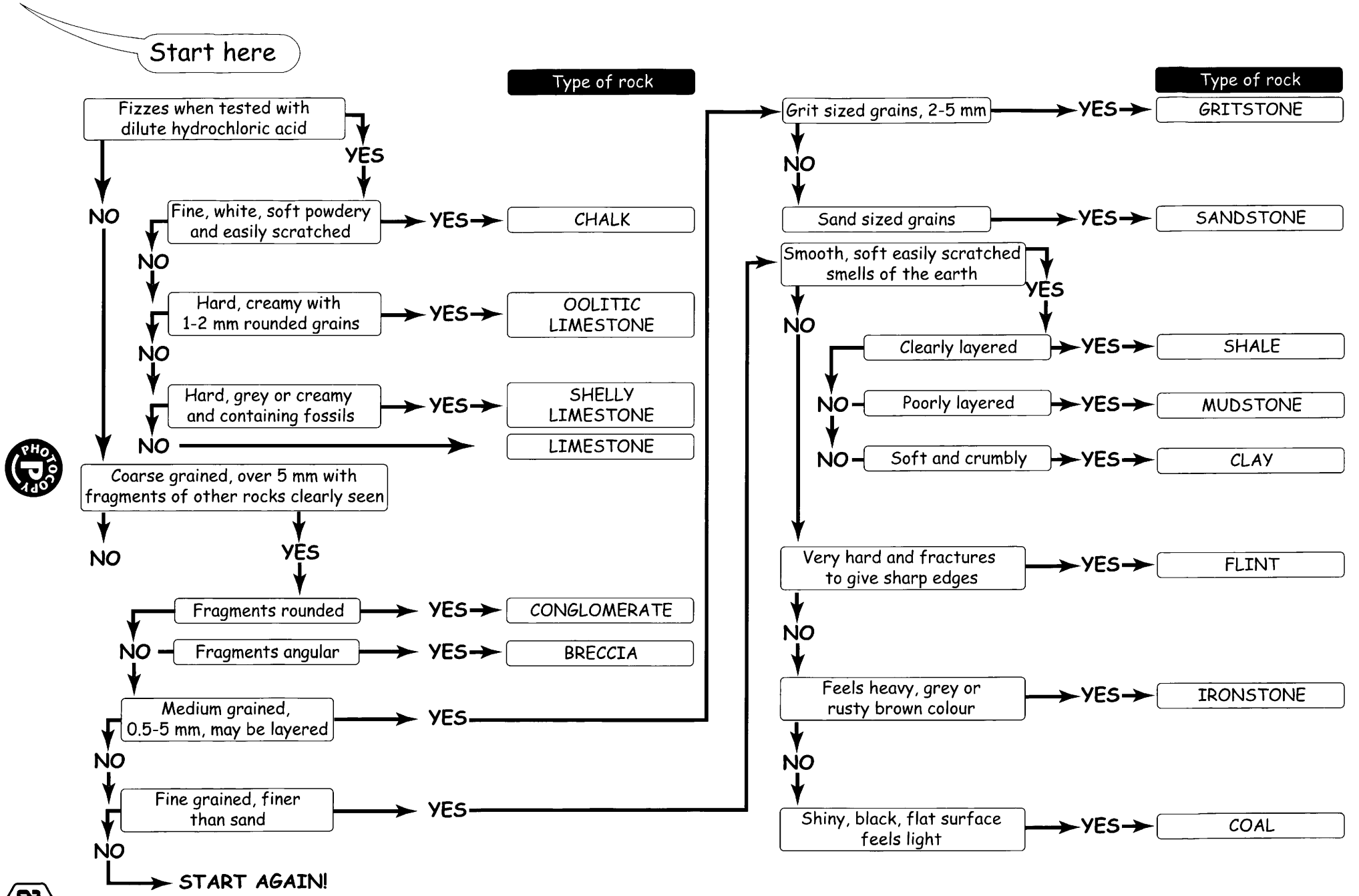
This is probably a rock made of microscopic crystals or grains difficult to make a decision about → YES → Try all the keys, begin with KEY 2

A hand lens or magnifying glass is useful for these rock identification activities



These are crystals locked together.

These grains are stuck together.


Start here
Type of rock
Fizzes when tested with dilute hydrochloric acid
YES
NO
Fine, white, soft powdery and easily scratched
YES
CHALK
NO
Hard, creamy with 1-2 mm rounded grains
YES
OOLITIC LIMESTONE
NO
Hard, grey or creamy and containing fossils
YES
SHELLY LIMESTONE
NO
LIMESTONE
Coarse grained, over 5 mm with fragments of other rocks clearly seen
NO
YES
Fragments rounded
YES
CONGLOMERATE
NO
Fragments angular
YES
BRECCIA
Medium grained, 0.5-5 mm, may be layered
YES
NO
Fine grained, finer than sand
YES
NO
START AGAIN!
Type of rock
Grit sized grains, 2-5 mm
YES
GRITSTONE
NO
Sand sized grains
YES
SANDSTONE
Smooth, soft easily scratched smells of the earth
YES
NO
Clearly layered
YES
SHALE
NO
Poorly layered
YES
MUDSTONE
NO
Soft and crumbly
YES
CLAY
Very hard and fractures to give sharp edges
YES
FLINT
NO
Feels heavy, grey or rusty brown colour
YES
IRONSTONE
NO
Shiny, black, flat surface feels light
YES
COAL

Start here

Fine grained, crystals less than 1mm, only seen with a hand lens.

YES

NO

Name of Rock

Lightweight, full of holes → YES → PUMICE

NO

Glassy → YES → OBSIDIAN

NO

Dark in colour, grey or red → YES → RHYOLITE

NO

Dark in colour, green or black → YES → BASALT

Medium to large grained, with crystals large enough to see without a hand lens

YES

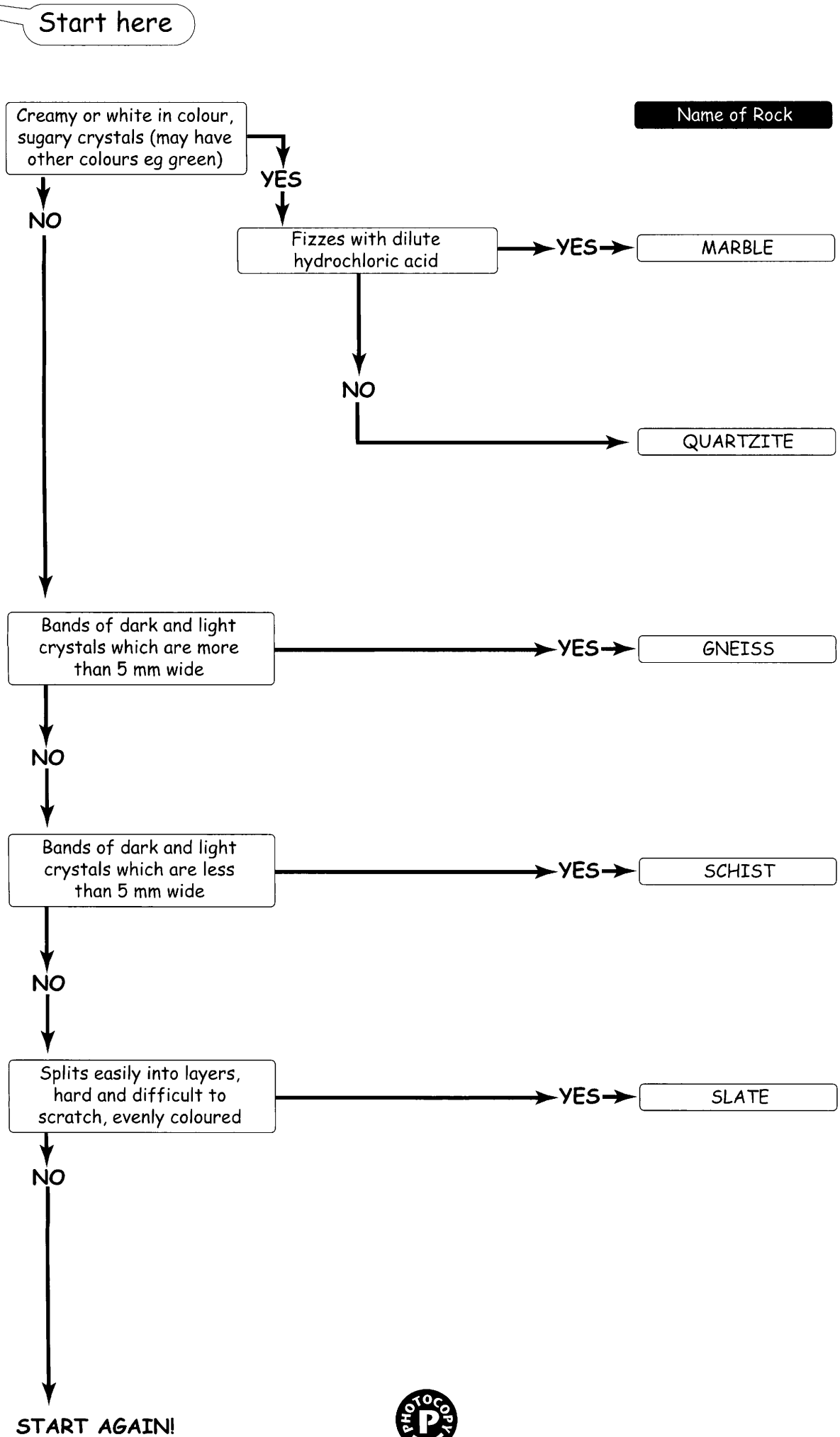
NO

Made mainly of light coloured crystals → YES → GRANITE

NO

Made mainly of dark coloured crystals → YES → GABBRO

START AGAIN!



Key ideas and activities

Rocks are naturally occurring and used for a variety of purposes

(a) Make a collection of rocks and discuss other words used for rocks eg pebble, stone, boulder.

(b) Brainstorm the names of different types of rocks that the children may know. At this point it may be necessary to distinguish between natural rock and manufactured materials such as concrete that they call rock.

(c) Identify where rock is used in the environment, by looking at some pictures or photographs, or preferably going outside on a local trip into a churchyard, town or school grounds.

(d) Stone trail. Identify and chart the more common stones/rocks/bricks, include classifications such as natural or man-made, colour, where it was seen, use, age, damage.

(e) If you are near the sea, collect things from the beach; rocks, pebbles, shells, driftwood, seaweed and glass. Discuss the natural and man-made items. The collection can be used later to discuss how the sea and weather has affected them.

Rocks maybe grouped according to observable features

(a) Carefully observe rocks with a magnifying glass, draw and describe texture and colour.

(b) Let the children group the rocks according to their own criteria.

The children could then be shown the characteristics of six common rock types.

A simple rock identification based on six common rock types

Internet

(1)	Large crystals different colours	GRANITE
(2)	Sand grains, rusty colour.	SANDSTONE
(3)	Dark grey, splits into layers.	SLATE
(4)	Fossil shells, pale colour	LIMESTONE
(5)	Small, mostly black, crystals.	BASALT
(6)	White, sugary crystals.	MARBLE

(Reproduced by kind permission of John Reynolds ESTA.)

Rocks maybe grouped according to their properties

Discuss the importance of various properties of rocks (eg hardness) with the children in terms of the weathering and erosion that may take place to rocks that may be used for example in building. They may see it for themselves in the local environment on gravestones, walls and stone buildings.

Set up a series of activities that can be done to test properties:

Word processing

(a) **Hardness** Scratch test – Make a 'hardness' chart by carrying out a scratch test. Make only one scratch and if for example marble leaves a clear mark on the sandstone, then the marble is harder than the sandstone. Harder 'rocks' will scratch softer 'rocks'. Older children could scale the rocks 1-10, as in 'Mohs' scale. Other materials can also be tested and scaled accordingly.

Scratcher / Material	Chalk	Slate	Flint	Sandstone	Marble	Coin	Plastic counter
Chalk							
Slate							
Flint							
Sandstone							
Marble							
Coin							
Plastic counter							

(b) **Permeability** Using a dropper and water, see what happens when water is dropped onto different rocks. Some rocks will soak up the water, others will allow the water to sit on the surface. A simple observation test for younger children.

Safety!

- Goggles should be worn when shaking or scratching rocks, or using acid.
- After handling rocks and soils hands must be washed or use plastic gloves.
- Soil samples should be checked for broken glass and animal faeces.

(c) **Porosity** The above test can be quantified by older children. Weigh the rocks dry, then immerse them in water. Bubbles can be seen as air from the pores in the rocks comes out. Leave for about 5 minutes. Which rock absorbs most water? Pat the rocks dry and weigh them again. The most porous rocks will have the largest weight gain.

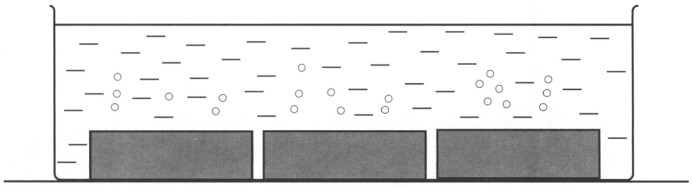
Investigate which is the most porous brick? This test can be done with different bricks if you can acquire them. Different bricks are used for different parts of a construction. Hard, non-porous bricks must be used for the damp-proof course of a house where the bricks are in contact with the soil. More porous bricks can be used for internal walls. The results of these tests can be put into a table and the relevance of them to the everyday use of rocks discussed. Rocks which

do not wear easily may be used for buildings, but because they are hard, they are difficult to cut and therefore expensive to use.

Use bricks that are the same size but may be different colours.

What are the bubbles?

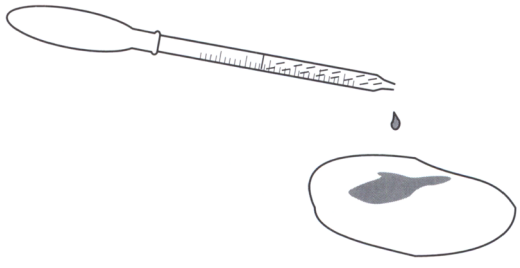
Bricks in Water



Use kitchen scales that go up to 3 kg.

(d) Effect of acid Using a dropping pipette and strong vinegar, see what happens when vinegar is dropped onto the rocks. Dilute hydrochloric acid (0.5 M where M indicates concentration in mol dm^{-3}) may also be used and works better on marble and calcite. (Try your local secondary school if this is not available from your primary supplier.) The calcium carbonate in **limestone, calcite, chalk** and **marble** will react with acid.

The chalk fizzes when you drop vinegar onto it. Use good quality, it's stronger.



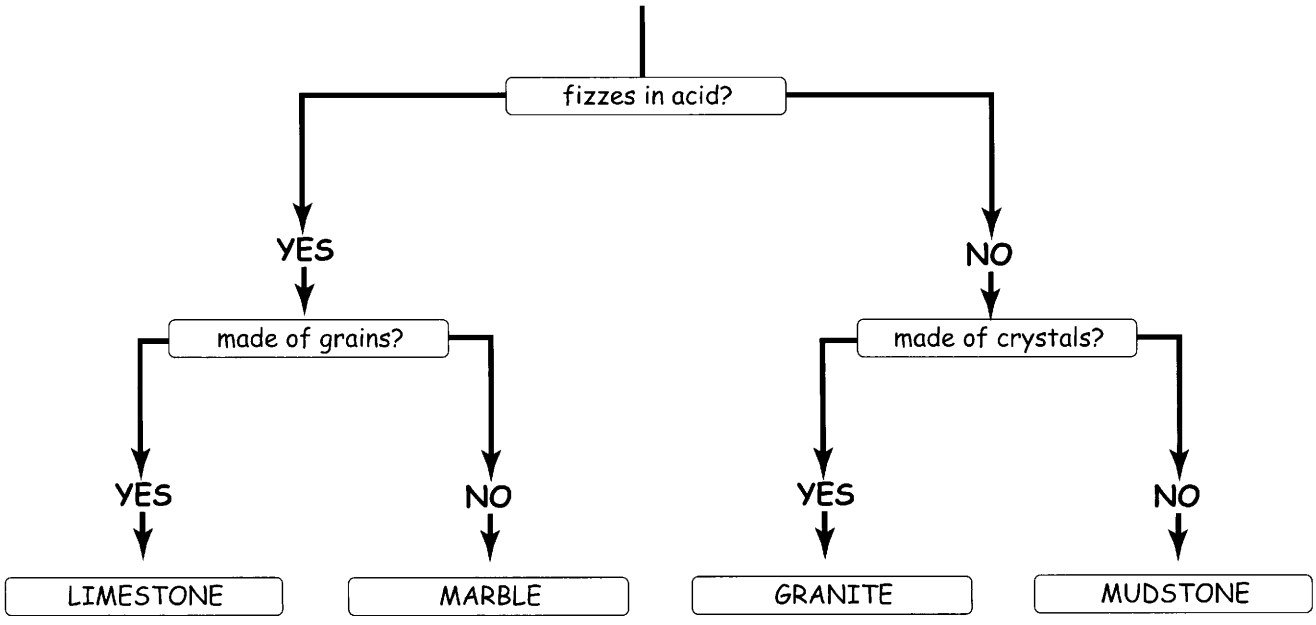
Even if this is carried out as a demonstration, it is good practice to make the children wear goggles. Discuss 'Acid Rain' (acid from pollutants in the atmosphere dissolved in rain as it falls).

(e) Magnetic Are any of the rocks magnetic? (Lodestone/magnetite is and was used for compasses on ships. It could be borrowed from a local museum.)

(f) Electrical conductors Older children can test for conductivity. Although not magnetic, graphite is a conductor.

(g) Using a key Older children can be given a rock and by carrying out simple tests and observations may identify it using a key. Younger children may use a simpler key. An example is shown overleaf.

This key can be used to name rocks.



(a) Which **two** rocks fizz in acid?

_____ and _____

(b) Maria wants to make a statue.

It must **not** be damaged by acid rain.

It must be made of crystals.

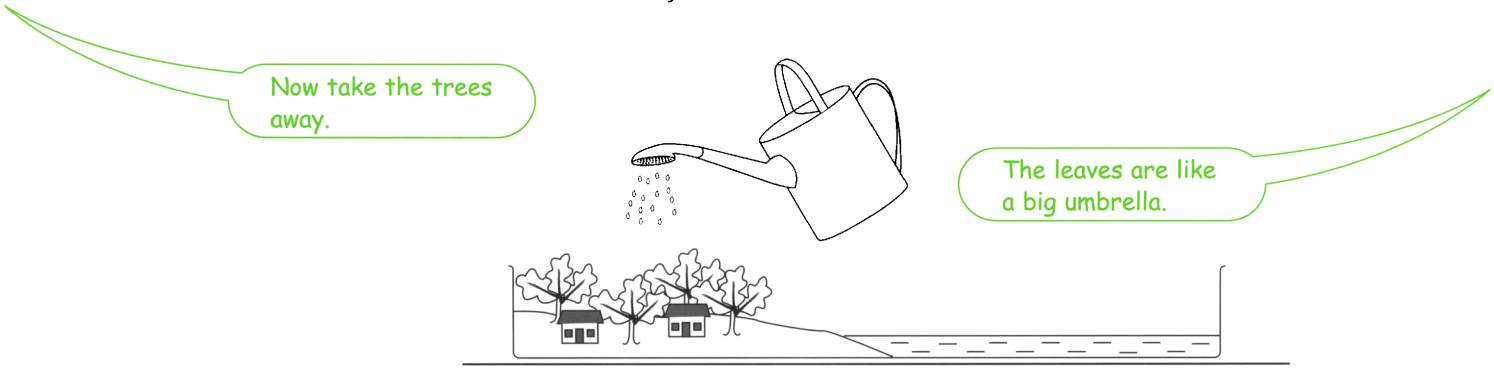
Put a (ring) around the best rock to use.

limestone **marble** **mudstone** **granite**

Rocks breakdown to form the basis of soil

(a) **Rocks in a box (or plastic bottle)** Using rocks of similar size put them in a container with and without a small amount of water and get children to take turns shaking vigorously. The effect of weathering and erosion on different rocks can clearly be seen.

Erosion of the land A demonstration to show children how land may be eroded and the effect of de-forestation. Use a large, shallow, waterproof tray and put soil one end to represent the land. Leafy twigs, which represent trees and small, toy houses can be added. Inthe space the other end make a 'sea' from tap water. Using a watering can, 'rain' heavily on the land. The leaves catch most of the water and protect the land and houses. If the 'trees' are removed and it 'rains' again, the land and houses start to move. The land may slip into the 'sea'. This is a very effective demonstration.



Soil types to use: clay, peat, sandy, prepared compost, garden loam
You could use the concept cartoon ***Sandcastles*** here, but it may be more appropriate for Mixing and dissolving materials.

To look at the composition of and compare different types of soil

(a) Using a magnifying glass let the children look at different types of soil and describe the colour, feel and smell. Squeeze a handful of each soil; clay clumps together and sandy soil crumbles apart.

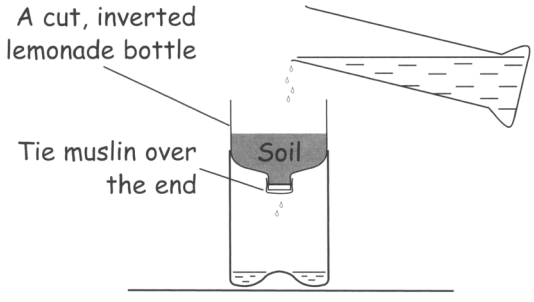
(b) **Sieving soil** Using graded sieve sizes, the soil can then be sieved into different sized particles and more closely observed for signs of animal and plants.

(c) Mix a sample of soil with water in a jar with a lid. Shake and leave to settle. This can be done with different types of soil to see the different layers settle out. Do they all take the same time to settle? Is there anything floating on the top, why do you think this is?

(d) As an extension activity, different samples of soil can be weighed, dried in an oven or over a radiator and re-weighed to see the water content. **Investigate** which soil holds most water.

(e) **Permeability** Using a funnel over a beaker, or a lemonade bottle cut in half with the top turned upside down over the bottom, tie muslin (or old nylon curtain) over the open stopper end to stop the soil falling through. Put soil into the funnel part and run water through it. Repeat with different soils. **Investigate** which soil is the most permeable.

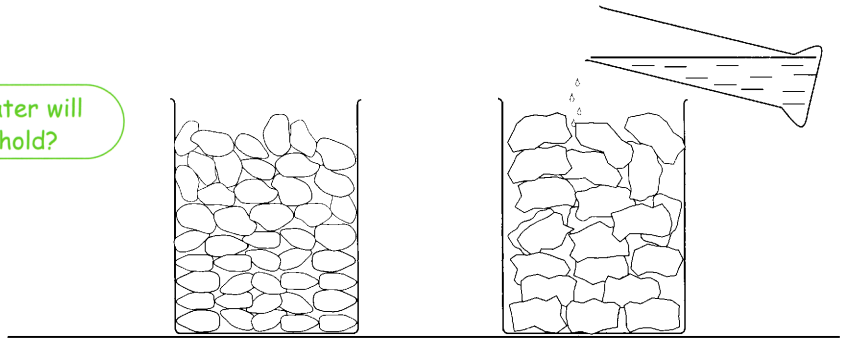
How much water is coming through the soil? Is there any on the surface?



Keep the amount of water and soil the same each time.

(g) **Air spaces** are important in soil for the things that are living and growing in it. Different soils have different amounts of air and the air spaces can be measured. Try this activity first. Using marbles, large stones, gravel, small stones and cubes fill beakers/identical jars. Now pour water from a measuring jug. Which jar needed most water to fill the air spaces? Repeat this with soils.

How much water will each beaker hold?



(h) **Acidity** Older children may test for this by adding distilled water to the soil, shaking then filtering the water off. This is then tested with Universal Indicator solution or papers. Commercial kits can be easily bought from garden centres or school suppliers. It can be a difficult test to get clear results, so it is a good idea to test the soil before letting the children do it.

Internet

Using secondary sources Videos, photographs and pictures are useful to show ways in which rocks are used and how weathering and erosion affect them and the natural landscape. The dangers of cliff tops and damaged buildings can be discussed. Children can access more information about volcanoes etc using CD-ROMs and the internet.

star* Poetry
by Michael Rosen

Yellow Rock As an introduction with younger children to talking about and looking at rocks generally. With older children, to introduce the origin of rocks and actions of volcanoes.

Yellow Rock

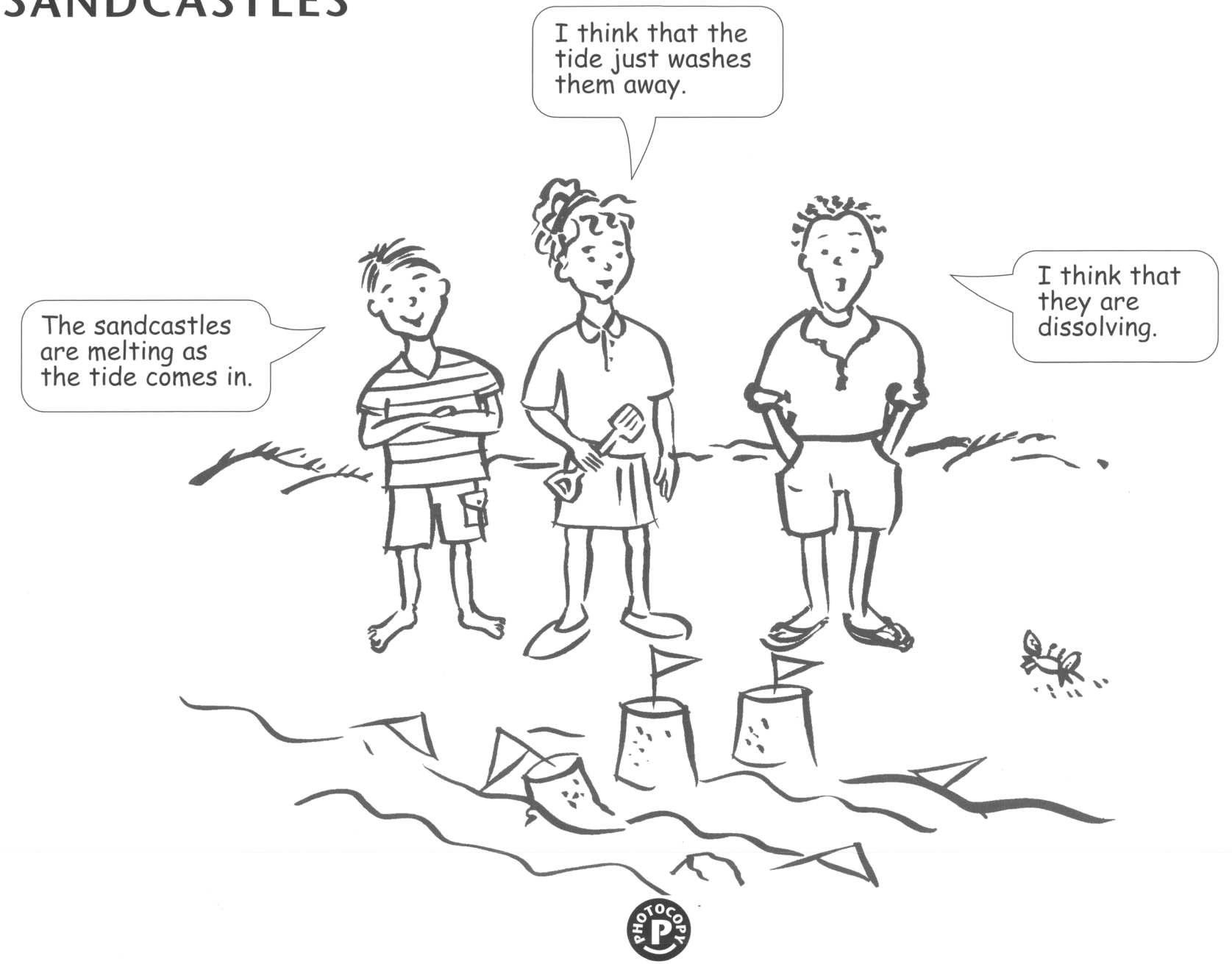
On holiday
on an island in Italy
we saw an old volcano.

We climbed up the side of it
and I picked up
a bit of yellow rock
and put it in my shirt pocket.

By the time
we got back
the stone
had made a hole in my pocket.

SANDCASTLES

RS•C



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CONCEPT CARTOONS

Sandcastles

The distinction between melting and dissolving is a common area of confusion for children. They can clarify the meaning they attach to both of these terms by investigating the situation shown in the concept cartoon. A tray full of sand can be used to model the effect of the tide on sandcastles. Observation of other changes in materials, such as melting chocolate or dissolving sugar, will be a useful complement to their investigation.

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SOLIDS, LIQUIDS AND GASES

Science background for teachers

VOCABULARY

Words to describe the different states of matter; solid, rigid, liquid, fluid, flow, pour, gas, gaseous state, melting, freezing

Names of solids, liquids and gases; ice, water, vinegar, oil, lemonade, oxygen, carbon dioxide, methane, helium

A solid has a definite shape that remains the same unless a force is acting upon it. The particles in a solid are rotating, vibrating or moving about a fixed position, close to each other. A solid normally occupies a slightly smaller space than the liquid, (except for ice, which takes up more space than liquid water). Some solids are made up of small particles eg sand. They can be poured like a liquid but the shape can be changed within the container, for example, when flour is put into a bowl, a well can be made in the middle.

A liquid has no fixed shape but a fixed volume and takes on the shape of its container. The molecules in a liquid move more and have more energy than particles in a solid but still remain in close contact with each other. Children often only think of water when talking about liquids, so it is worth beginning by brainstorming all the liquids that they know. Different liquids behave in different ways, some move more easily than others – they are less viscous.

A gas has no fixed shape or volume and will always spread out to fill the container it is in. The particles have a lot of energy, moving around in a random way, hitting other particles and the walls of the container.

All matter is made up of particles which have energy and move, the more energy they have the more movement there is. When a solid is heated it gains energy, the particles move more and it changes to a liquid state. If even more energy is supplied, more movement occurs and it changes to a gaseous state. If a gas is heated it gains more energy and takes up more space (expands). The concept of **gases** is difficult for young children. Older children can discuss gases with which they should be familiar as suggested below.

Methane is natural gas, a by-product of oil made under the sea from the decomposition of small plants and animals. It is the gas that is used as a fuel in our homes.

Steam is the name given to the gaseous state of water at or above 100 °C and is not visible. Water vapour is the gaseous state of water below 100 °C and is visible as tiny water droplets.

Helium is a gas that is completely non-reactive and has a low density which is why it is used as a lifting gas in fun balloons and airships.

Carbon dioxide is easily produced in the classroom. It is non-toxic, soluble in water and forms 'dry ice' at low temperatures. It is a product of respiration by plants and animals and used by plants to photosynthesise.