

Separating mixtures: how we concentrate natural materials: teachers' notes

Level

This activity is designed for students aged 11-14.

Topic

The activity covers methods of separation of mixtures as a class practical and then applies ideas about separation to separating mixtures of minerals on the basis of their different physical properties. National Curriculum statements for England and Wales both mention distillation and chromatography but also mention or imply the need to know about 'other appropriate methods'. This topic fulfils that requirement.

Description

Students are shown a piece of **granite** and see that it is clearly a mixture. They are then presented with several simple mixtures and invited to devise and try out ways of separating them. Finally the ways in which some real mixtures of **minerals** are separated are discussed and tested.

Context

Students should have already done some work on separating mixtures in which case the teacher will probably wish to stress the mineral separation aspect.

Teaching points

It is important to stress to students the principle that in order to separate the components of a mixture, there must be a property difference between the components.

Timing

Two approximately one-hour teaching periods.

Apparatus

- Eye protection
- Tweezers
- A large, shallow plate made from metal or plastic.
- Small magnets (wrapped in Clingfilm™ to make removal of iron filings easier).
- Access to standard laboratory apparatus including beakers, flasks, funnels (and filter paper) Bunsen burners, tripods, gauzes, heatproof mats.
- An ultraviolet lamp.
- A bucket.
- A 'jigger', made from a 30 cm length of hard transparent plastic tube, of about 3 cm internal diameter, with a piece of 1 mm metal gauze stuck to the bottom. (Heat the gauze to red heat, then quickly press the plastic tubing onto the gauze and leave it to cool.)

- A 'buddle' made from an approximately 2 m length of square cross-section plastic guttering. Into this are glued at roughly 15 cm intervals 1 cm high pieces of cork tile cut to fit the inside of the guttering. These form barriers across the guttering, see Figure 1.

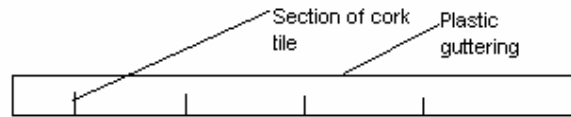


Figure 1 A buddle

Chemicals

- A large sample of granite in which the three components; mica, quartz and feldspar are easily seen. Rock samples can be obtained from a geological supplier. Click here for details of some suppliers <http://www.earthscienceeducation.com/suppliers>
- A 'charge' of about 100 g of medium-sized crushed coal and 'rock waste' (about 50 of each by volume). Fragments should be 2 to 5 mm in diameter, but not dust. A second 'charge' of coal dust and powdered 'rock waste', in the same proportions.
- Galena and calcite (about 50 : 50 by volume) – about 50 cm³. For best results, this mixture should be fairly fine – no coarser than a fine gravel.
- Marbles of two different colours – about 100 marbles in total
- Sand and iron filings (about 50 : 50 by volume) – about 500 cm³
- Sand and salt (about 50 : 50 by volume) – about 500 cm³
- Sawdust and sand (about 50 : 50 by volume) – about 500 cm³
- Sand and iron pyrites (about 50 : 50 by volume) – about 500 cm³
- Fluorite and calcite (about 50 : 50 by volume) – about 50 cm³ – both these are similar in colour (whitish)
- Black sand and iron pyrites (iron sulfide, 'fool's gold') (about 50 : 50 by volume) – about 50 cm³

Safety notes

- Wear eye protection.
- The ultraviolet lamp should not emit radiation of wavelength shorter than 300 nm. Ensure that the light is not viewed directly.
- It is the responsibility of the teacher to carry out an appropriate risk assessment.

The activity

Show the class a sample of granite. Ask them to describe it and draw out the fact that it contains at least three different components, see Figure 2.

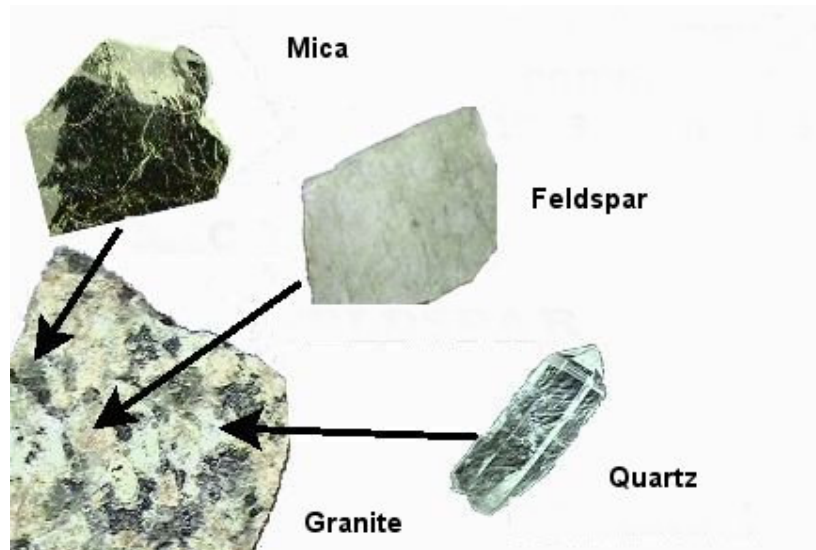


Figure 2 The composition of granite (modified from an original image by permission of the Utah State Office of Education)

The black or grey shiny mineral is called mica. (Mica is a mineral that can be used in the small windows in central heating boilers as it can withstand great heat. It can be made into vermiculite, which is used as loft insulation.)

The shiny, glassy and colourless mineral is quartz (Quartz is used in some types of watches and for making prisms, in glassmaking and in abrasives.)

The white, creamy or pink mineral is called feldspar and is used in the ceramic (pottery) industry as an additive to the clay.

Point out that to use these components, a method of separating mixtures is required.

Now give the class a set of mixtures and ask them to devise ways in which they could be separated using standard laboratory equipment. They may try out any methods that they suggest provided that they are safe and sensible.

Mixtures include (with a possible separation method in brackets):

- Marbles of two different colours (hand picking)
- Sand and iron filings (using a magnet or panning)
- Sand and salt (salt is soluble in water)
- Sawdust and sand (density difference – sawdust floats in water or can be blown away)
- Sand and iron pyrites (panning)

Draw out from the discussion of the results the fact that in order to separate a mixture, the components must have a difference in property, *eg* magnetic / non-magnetic, soluble / insoluble, low density / high density *etc*.

The following lesson, the teacher demonstrates some separation methods actually used to separate minerals.

Jigging

This method can be used to separate coal and rock waste on the basis of density. The jigger described here is a small-scale model of a method used industrially.

Jigging is accomplished by filling the apparatus about one-fifth full of 2 to 5 mm coal / 'rock waste' mixture and plunging the jigger up and down in a bucket nearly full of

water with just enough force to move the fragments. Given time, separation will occur. Keep the top of the charge below water level throughout for the best results.

The coal should lie above the 'rock waste' by virtue of its lower density.

It is worth recovering the materials later for future use.

Jigging is not very effective for separating the finer particles.

Jigging relies in part on the different relative densities of coal and waste products (coal about 1.3 g cm^{-3} , shale about 2.4 g cm^{-3}), and also on the settling velocities of particles in a liquid (water in the case of coal preparation). If the viscosity of the water is increased because of a large percentage of fine material, for example shale dust, the larger pieces of shale which would normally sink would begin to float, and would contaminate the coal. The physical size of a real jig, sometimes called a 'washbox' is very large, and takes up a great amount of plant area.

The fact that a jig uses water, and taking into account what has been said above about the need to keep that water relatively free of finely divided material a great deal of water is required. So the plant must be situated somewhere near to water. Coal preparation plants use a water clarification system to recycle water, but there is still a need for 'make-up' water from outside the plant. Disposal of this water can be a problem, but plants usually have a settling lagoon, where the solids sink to the bottom and the water can be returned, after being further cleaned, to streams *etc.* The water is very closely monitored to check for contaminants.

Buddling

This method also makes use of a density difference between two components of a mixture, for example galena (a lead-containing ore) and calcite. The buddle described here is a small-scale model of a method used industrially.

Set up the buddle on the bench so that one end overhangs a sink and the other end is raised about 35 cm above the bench. Place a bucket or bowl in the sink below the end of the buddle to catch the overflowing sediment and prevent sink blockages. Place some of the mixture of galena and calcite in the top end of the buddle and then gently pour in water from a jug or a length of rubber tube attached to the tap. The stream of water will carry the mixture down towards the barriers where the denser galena will be trapped and the less-dense calcite will be carried over the barriers and into the bucket in the sink. Some practice beforehand is recommended to estimate the optimum angle of the buddle and the flow rate.

Handpicking using ultraviolet light

Show the students the mixture of fluorite and calcite. There is no visible difference between the components to allow hand picking. Discuss possible solutions with the class (and demonstrate them if there is time). No satisfactory method will be found. Then shine the ultraviolet lamp on the mixture. The fluorite will fluoresce, making hand-picking a feasible option. Hand picking has been used in the past to separate shiny galena (an ore of lead) from gangue.

Panning

Prospectors for gold still use this method to separate dense, gold-containing, ores from sand on the basis of the greater density of gold. Place a little of the sand / iron pyrites mixture in a plate and part fill the plate with water. Swirl the plate so that the water carries the less-dense sand over the rim of the plate and into the bucket leaving the denser iron pyrites in the plate.

Further information

Further information about mining for minerals and separating mixtures of them can be found at <http://www.durham.gov.uk/durhamcc/usp.nsf/web/pages/killhope+index+page>. This relates to a mining museum in County Durham which could form the basis of a school visit for those close enough.