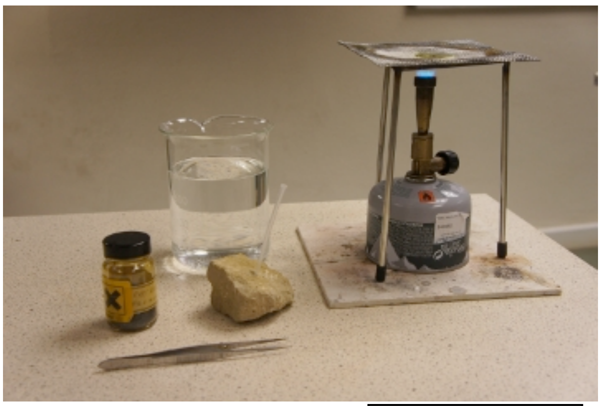
Interactive hydrothermal mineralisation
'The rock with the hole' hydrothermal mineralisation demo

This activity demonstrates how hydrothermal minerals form. It could be used as a simple illustration of the processes with minimal pupil involvement. But it can also be used as an interactive demonstration, to engage pupils in the thinking behind a scientific enquiry, as follows. Keep the apparatus and materials hidden from the pupils until they are needed.

1. Show pupils a photo of a mineral vein with a gap remaining in the middle, like this one.

A vein of the purple 'Blue John' variety of the mineral fluorite in a vein in the Peak District of England.

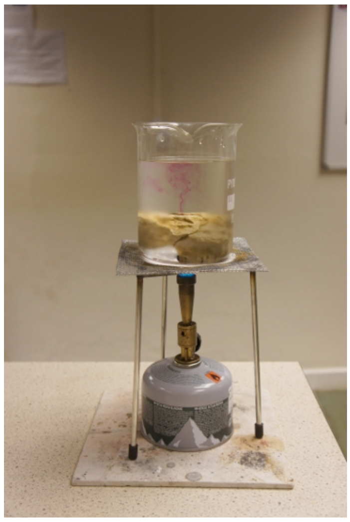
2. Ask them how the minerals could have got there.
   A. There must have been a hole in the rock through which the minerals came.
3. Show them a hand-specimen-sized rock with a hole in the middle, and ask, 'Is this the sort of hole you mean?'
   A. Yes



The apparatus

Photo: Chris King.

4. Tell them that rocks like this were originally formed without containing minerals like these; they were part of rock sequences underground. Ask them how the chemicals to form the minerals could have got into the hole.
   A. They must have been brought in by a fluid – a liquid is most likely, eg. water.
5. If they wanted to fill the hole in the rock with water, in the most natural way, ask how this could be done.
   A. Put the rock in a beaker and fill it with water until the rock is well covered.
6. Ask whether the water bringing the mineralising chemicals into the hole is most likely to flow in from above or below.
   A. From below, since there is much more rock that the mineralising fluids could have come from below rather than above.
7. Ask, how we could get water currents to flow through the hole in the rock, from below.
   A. By heating the water from below.
8. Ask why heating water would cause it to rise.
   A. Hot water rises, because it expands on heating and so has a lower density than the surrounding water.
9. Ask how we could make water rising through the hole visible and how we could show it was containing chemicals.
   A. Add coloured material to the water below the hole that will dissolve and colour the liquid.
10. Place a fine glass tube into the hole and, use tweezers to pick up and drop a crystal of potassium permanganate down the hole, then remove the tube.
11. Heat the beaker and watch the plume of permanganate-coloured liquid rise through the hole (the permanganate happens to be the same purple colour as the 'Blue John' in the photo above).
12. Ask, when the hot liquid containing dissolved minerals is naturally flowing upwards through underground holes such as cracks and joints, what causes the minerals to crystallise on the walls of the crack to form mineral veins.
    A. As the fluids cool, minerals crystallise.



A plume of purple potassium permanganate-dyed liquid rising through the hole, on heating.

Photo: Chris King.

This demonstration can be carried out in the lab, but is even better done in the field, beside a mineral vein, using a camping heater.

The back up

Title: Interactive hydrothermal mineralisation

Subtitle: 'The rock with the hole' hydrothermal mineralisation demo

Topic: A demonstration of how hydrothermal fluids flow through rocks, presented in a way to interact with pupils.

Age range of pupils: 14 – 19 years and adults.

Time needed to complete activity: 10 mins

Pupil learning outcomes: Pupils can:
- describe how minerals veins form;
- explain how the model helps them to visualise hydrothermal mineralisation processes.

Context:
The mineralising chemicals dissolved in hydrothermal fluids have two possible sources:
a) when rocks deep underground are heated, the fluids they contain are able to dissolve minerals in the surrounding rocks more readily, and then the hot fluids rise;
b) when igneous magmas cool, at a late stage of cooling, a watery fluid rich in mineralising chemicals often separates and rises.

Common minerals found in hydrothermal mineral veins are shown below. The 'gangue minerals' are the common minerals in the vein that were formally thrown away, but may sometimes have value in their own right. The 'ore minerals' are the metal minerals most commonly mined from mineral veins.

Common gangue minerals		Common metallic vein ore minerals	
Mineral	**Composition**	**Mineral**	**Composition**
Quartz	SiO_2	Cassiterite	SnO_2 (mined for tin)
Calcite	$CaCO_3$	Galena	PbS (mined for lead)
Fluorite	CaF_2 (mined for fluorine)	Chalco-pyrite	$CuFeS_2$ (mined for copper)
Barite/ Barytes	$BaSO_4$ (mined for barium)	Hematite	Fe_2O_3 (mined for iron)

Following up the activity:
Ask the pupils why some mineral veins have bands of different types of minerals. This is because the waters that flow through the veins contain different mineralising chemicals at different times. Often 'mirror-image' banding occurs on either side of veins, allowing the sequence of mineralisation to be worked out.

Underlying principles:
Most hydrothermal mineralisation involves the following:
- rocks containing voids such as fractures or joints;
- sequences of rocks beneath the water table that are naturally full of water;
- hot watery fluids that rise because heating caused them to expand and so have lower density than the surrounding fluids;
- hot mineralising fluids, rich in dissolved chemicals;
- fluids that cool as they flow along voids, crystallising minerals on the walls as they do so;
- the original source of the mineralising chemicals was either, a) heated rocks deep beneath the surface, or b) crystallising magma.

Thinking skill development:
The discussion around this demonstration involves the pupils in construction, cognitive conflict and bridging as they try to bring together the reality of the mineral vein and the processes demonstrated by the model. If pupils are asked why they have answered as they have, metacognition is also involved.

Resource list:
- a hand-specimen-size rock such as limestone through which a hole of about 8 mm diameter has been drilled; it is surprisingly difficult to drill a hole like this, so an alternative is to make a 'rock' out of modelling clay, with a hole through the middle
- a beaker large enough to contain the rock easily
- a supply of water
- a glass tube that will fit the hole
- crystals of potassium permanganate (Safety Note: potassium permanganate is a strong oxidising agent and should be treated with care; it will also stain wet hands dark brown);
- tweezers
- a means of heating the beaker, eg. tripod, gauze, Bunsen and safety mat if in the lab, or camping stove, gauze and safety mat if used in the field; safety glasses
- matches.

Useful links:
Hydrothermal mineralisation is occurring today, in oceanic ridge areas beneath the oceans. Here mineralising fluids heated by hot magmas beneath, rise and flow out of the ocean floor, forming chimneys called black smokers, which eject hot mineral-rich fluids. You can see one of these in action at: http://ocw.mit.edu/courses/ earth-atmospheric-and-planetary-sciences/12-742-marine-chemistry-fall-2006/. Modern mineral veins are probably being created beneath the ocean bed during black smoker activity.

Source: Devised by Chris King of the Earthlearningidea Team.