Volcano in the lab
Modelling igneous processes in wax and sand

Prepare a 500 ml glass beaker as described in the "Resources" section below and place it on a tripod, ready to light the burner. Before the burner is lit, ask the class to predict what will happen as the contents of the beaker heat up. If they need prompting, you could ask them:
- Which will melt first – the wax or the sand? (*The wax)*;
- What will happen to the wax once it has melted? (*It will rise*);
- Why will it rise? (*Molten wax is less dense than water*);
- Will any of the molten wax reach the top of the water? (*Yes – at least some of the wax usually 'erupts' onto the surface of the water and spreads out to form a sheet of molten wax*).
- Will any of the molten wax set in the water? (*Yes, especially if the water has been chilled beforehand*);
- Will the molten wax convect round the beaker? (*No – the beaker is too restricted and the wax is too buoyant*).

Then heat up the beaker and ask students to watch carefully throughout, from a safe distance or behind a safety screen. Quite often, very little seems to be happening, until the wax suddenly 'erupts'. Ask how it is that molten wax can reach all the way to the surface, even though the water around it is quite cold (*quite often, a tube of wax forms in the water, through which the rest of the wax rises, effectively insulated from the surrounding water by the consolidated wax tube*).

(Remove the burner whilst there is still a little wax left on the bottom of the beaker).

The wax volcano in action – in this example, a surface "lava flow" is fed by three feeder pipes, with "intrusions" building up near their bases – but all eruptions are different.
(Photo: *Peter Kennett*)

……..……………..

The back up

Title: Volcano in the lab

Subtitle: Modelling igneous processes in wax and sand

Topic: Modelling the rise of "magma" through the "crust", and observing how some of it can erupt onto the surface, representing a lava flow, whilst some sets within the water mass, representing an igneous intrusion.

Age range of pupils: 12 – 18 years

Time needed to complete activity: 10 minutes for the activity, plus about 15 minutes to set up the beaker.

Pupil learning outcomes: Pupils can:
- make predictions based on their previous experience of heating materials;
- debate their detailed predictions with each other;
- observe a sequence of events accurately and explain the outcome;
- describe how the model relates to reality;
- explain how magma can either reach the surface to produce volcanic eruptions, or 'set' (become solid) below ground to form intrusions.

Context: The activity can be used during the course of both science and geography lessons to illustrate the principles of igneous activity, both at the Earth's surface and below.

Following up the activity:
Discuss the applications of the model to the real world, e.g.
- The sand and water represent layers in the Earth's crust.
- The wax represents the upper mantle, which is normally solid, but may be locally melted at a point source.
- Just as the wax rises because of its lower density than its surroundings, so magma may rise to be intruded into the crust, or it may erupt onto its surface to form lava flows.
- Wax reaching the surface is very mobile and spreads out into a sheet, simulating the widespread "plateau lavas", like those of Iceland or the Antrim Plateau in Northern Ireland, where huge volumes of lava erupted from fissures rather than from central volcanoes.
- "Feeder pipes" and fissures occur naturally too, and effectively insulate the rising magma from the colder ambient environment through which they are passing, just as in the beaker.

- The shapes of the consolidated wax in the water are similar to some of the shapes of real igneous intrusions. These can be revealed by lifting off the wax "lava" after it has set and by pouring away some of the water, to simulate erosion in the real world.
- Students can be challenged to say in which respects the model does **not** represent the real world. (*In reality, the surface lavas would set much more quickly than the intrusive masses, because of the lower ambient temperatures at the surface. Mostly, the real rocks will crystallise as they cool, not merely congeal, as happens with the wax. Using water to represent layers of rock may prove a difficult concept for some, but there is no other way of making the processes visible*).
- The model can be related to the theory of plate tectonics.

Underlying principles:
These are mostly covered in the text above. Some students (and teachers!) struggle with the concept that the mantle is essentially solid, and yet it can allow movement of plates above it. It is also the source of many magmas. Seismic investigations prove that the mantle is at least 95% solid, with any liquid portion existing as interstitial fluid between the grains of rock in the worldwide zone known as the asthenosphere. Where the mantle does partially melt, the resultant magma chambers are very localised, and are seldom more than a few kilometres across. It is also possible for the rocks of the lower crust partly to melt to produce magmas.
The reasons why some magmas reach the surface and others do not are complex, and mostly depend upon the temperature of the magma and its dissolved water content – a hotter, "drier" magma is more capable of reaching the Earth's surface than a cooler "wetter" one.

Thinking skill development:
- Prediction of the outcome of heating the wax involves construction;
- Explaining why students' predictions were not always fulfilled involves cognitive conflict;
- Metacognition is involved as the group discusses the outcomes;
- Linking the model to the real world requires skills in bridging.

Resource list:
- one 500ml glass beaker
- coloured candle wax
- washed sand
- cold water (preferably chilled in a fridge)
- a Bunsen or camping burner, tripod, gauze, heatproof mat, gas supply, matches
- eye protection, or safety screen

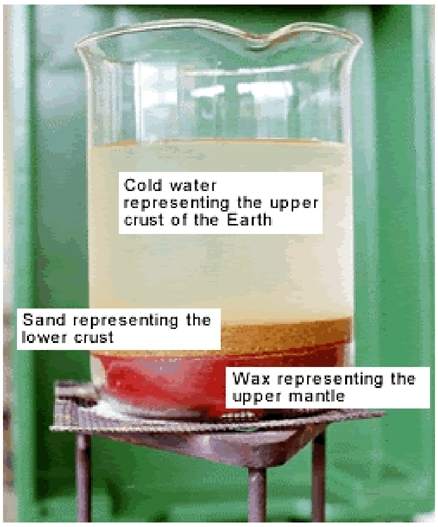
Note: Although a wax 'eruption' may appear to be a dangerous activity, experience has shown that the worst that can usually happen is that the beaker cracks if it is heated too strongly, allowing some warm wax and water to trickle down.

The model should be prepared before the lesson by melting wax into the base of the beaker (about 1cm thick) and letting it set. Washed sand is added, again about 1 cm in thickness) and the beaker topped up with cold water until it is about three-quarters full. After adding the water, make sure the sand has an even thickness across the base of the beaker. To ensure some "igneous intrusions" the model can be chilled in a fridge before the lesson.

Useful links: www.earthlearningidea.com Carry out the activities in the related titles in the Earthlearningidea series, e.g. *A mantle plume in a beaker- modelling processes at a constructive (divergent) plate margin; Partial melting – simple process, huge global impact.*

Source: Based on the workshop titled "The Earth and plate tectonics", Earth Science Education Unit (ESEU), © The Earth Science Education Unit: http://www.earthscienceeducation.com/ licensed under an Attribution-Noncommercial-Share Alike 3.0 Unported Creative Commons licence http://creativecommons.org/licenses/by-nc-sa/3.0/

This activity was originally devised by Mike Tuke, and published in his *Earth Science Activities and Demonstrations* (1991) by John Murray.

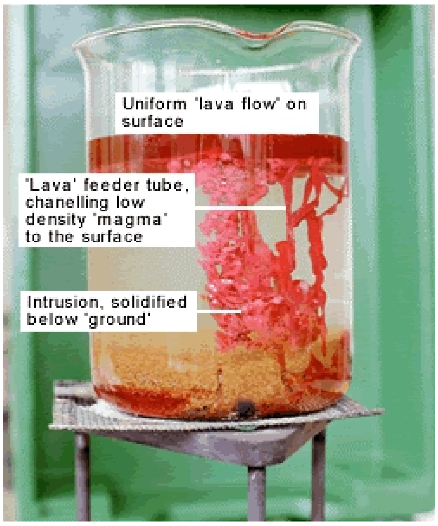


1. The set up, before heating

2. Molten wax begins to rise

3. A feeder pipe channels wax to the surface

4 and 5. More feeder pipes develop and “intrusions” form as wax sets within the cold water



6. The geological significance of the activity

The wax volcano in action
(Photos: *Peter Kennett)*