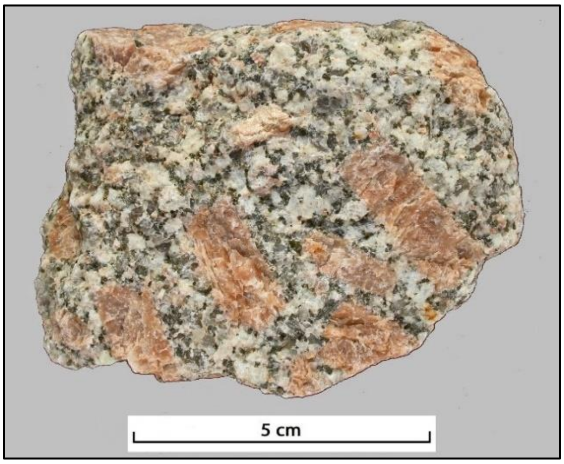
Partial melting model and real rock
Comparing a model with reality to develop understanding of the partial melting process

Compare the partial melting Earthlearningidea model (found at http://www.earthlearningidea.com/PDF/82_Partial_melting.pdf) with a real igneous rock like granite, to show how the model can help us to understand how the partial melting of rocks really works.

This beaker, containing a mixture of gravel and chopped candle wax, was heated until the contents partially melted – that is, the wax melted

This beaker shows what happened. The melted wax flowed to the top. The result is two layers of different compositions – a layer of candlewax on top and a layer of mixed gravel and candlewax below.

(*Chris King*).



Granite specimen. (*Peter Kennett for ESEU*).

Show the pupils the partial melting model and a specimen of igneous rock, like granite, and ask them the questions shown in the table. Likely answers, probably after 'prompting', are shown.

Partial melting model	Granite specimen
What do the two mixtures contain?	
Grey gravel and red chopped candlewax	• pink orthoclase feldspar, • white plagioclase feldspar, • black biotite mica, • grey quartz
If each were steadily heated, which materials would melt first?	
• Candlewax would melt first, at around 70ºC • If the gravel were made mainly of quartz, it would not melt until around 573ºC	• Quartz would melt first, at around 573ºC • The normal melting sequence then is: ▪ orthoclase ▪ biotite and/or plagioclase
What would happen to the molten material?	
Being liquid and hot, and therefore of lower density, it would rise, leaving the solid material behind	
What might the result be?	
Separation, with a layer of wax on top and a mixture of wax and gravel below	Separation, with a quartz-rich magma above and crystals of the minerals that had not yet melted below.

The discussion shows how partial melting can produce melts and rocks with different chemical compositions. In the wax/gravel partial melting model the result is an upper layer 'enriched' in wax and a lower layer 'depleted' in wax. For the granite, the result is a liquid (magma) enriched in the components of quartz (SiO_2, silica) and a remaining rock depleted in silica.

What is the chemical difference?	
An upper layer of wax	A magma rich in silica that will rise
A lower layer of gravel and wax	A rock depleted in silica left behind

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The back up

Title: Partial melting model and real rock.

Subtitle: Comparing a model with reality to develop understanding of the partial melting process.

Topic: A consolidation exercise on partial melting, to ensure that students understand how a model mirrors processes in real rocks.

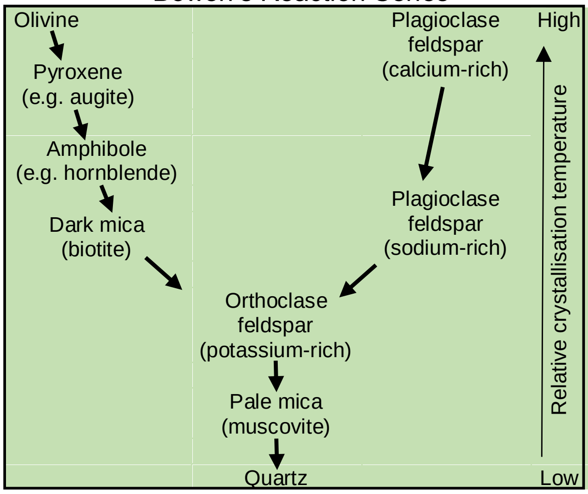
Age range of pupils: 14 – 18 years

Time needed to complete activity: 10 minutes

Pupil learning outcomes: Pupils can:
- use the gravel/wax partial melting demonstration to explain how partial melting of a rock will produce a magma with a different chemical composition from the original rock (often richer in oxygen/silicon and poorer in iron/magnesium);
- explain the differences and similarities between the model and reality.

Context:
The partial melting process can be directly linked to the key rock-forming minerals by reference to Bowen's Reaction Series, shown below. Bowen investigated the melting and crystallisation temperatures of a series of the minerals commonly found in igneous rocks, to discover the order of melting (and therefore their order of crystallisation too).

Bowen's Reaction Series



The series shows that in a quartz-containing rock, like the granite above, quartz is the first mineral to melt, followed by muscovite, orthoclase, then biotite and sodium-rich plagioclase, etc. For a rock that contains only the minerals near the top of the series, the melt order is still up the series, but begins above the bottom.

The minerals on the left hand side of Bowen's Reaction Series are rich in iron and magnesium; those on the right are rich in calcium and sodium.

Following up the activity:
Gabbro contains iron/magnesium-rich olivine, pyroxene, amphibole together with calcium/sodium-rich plagioclase. Discuss with the pupils what would happen if this were partially melted.

(*A. Of the iron/magnesium-rich minerals, amphibole would melt first, then pyroxene, followed by olivine. At the same time, the plagioclase would be melting, sodium-rich plagioclase first and calcium-rich plagioclase later. So the first melt would be rich in the constituents of amphibole and sodium-rich feldspar. If the melt were removed, the resulting rock would therefore be depleted in the constituents of these minerals.)*

Underlying principles:
- In a rock containing a mixture of minerals, some minerals melt before others – this is called partial melting.
- If the melt formed by partial melting is removed, then the melt is richer in the constituents of the first minerals to melt, and the remaining rock is depleted in those constituents.
- The physical process of partial melting produces chemical differences in the rocks.

Thinking skill development:
Thinking through the effects of partial melting on the model and on the real rock is a construction exercise; the comparison exercise involves cognitive conflict and bridging between the model and reality.

Resource list:
- two small beakers prepared as described in the '*Partial melting - simple process, huge global impact'* Earthlearningidea
- a specimen of igneous rock, such as granite

Useful links:
Animated videos of partial melting can be found by typing "partial melting" and 'video' into a search engine like Google.

Source: Devised by Chris King of the Earthlearningidea Team.