Differentiation

Partial melting *TE*

Imagine heating chocolate chip cookies, the chocolate will melt first.

Differentiation using Smarties *A P F 15 min*

Two packets of Smarties are scattered over a tray which is the magma chamber. Each mineral is allotted a different colour of Smarty. Students remove each mineral or group of minerals in turn and place them in a layer at the base of the "magma chamber" They do this either as the teacher tells them or using a very simple temperature of crystallisation chart for the minerals.

Differentiation using cards *A P or I F 15 min*

This activity is to help students learn how the minerals change and how the composition of some of those minerals change. Students are given a packet containing 80 pieces of coloured card. Each colour represents a different mineral and changes in mineral composition are shown by changes in shade. The mineral name and chemical composition is given on each piece of card. Students scatter these on their desk. The teacher calls out which minerals are crystallising and sinking to the bottom of the magma chamber. Students take those minerals and place them in a layer close to them on the desk. Subsequent minerals are placed on top of the first layer.

Differentiation of 100 tons of magma *Pa I F 30 min*

Students are given a sheet detailing the tonnage of each mineral that crystallises and sinks to the bottom of the magma chamber within a given temperature range. They use this information to draw the magma chamber with the different layers containing different minerals.

Gravity settling *Pa I 1 hour*

To calculate the speed of fall of crystals in a basic magma

Students calculate the speed of fall for the 3 minerals using the following densities for the minerals and magma and the Stokes' equation.

For basic rocks

Olivine, 3500 kg m^{-3} augite 3400kg m^{-3}

plagioclase (an) 2700kg m^{-3}.

Basic magma at 1200°C 2600 kg m^{-3}

Viscosity of basic magma at 1200°C is 30 kg $s^{-1}m^{-1}$

The speed of fall is given by Stokes' equation.

$$\text{Velocity} = \frac{(\text{density of mineral} - \text{density of liquid}) \times g \times d^2}{18 \times \text{Viscosity}}$$

g = 9.8m s^{-2}. d = diameter of grain in metres. The densities are in kg m^{-3} and the velocity in m s^{-1} Viscosity kg $s^{-1}m^{-1}$

Gravity settling experiment E P F 30 min per mineral
The speed of fall of olivine, augite and plagioclase is measured in glycerol and then adjustments are made to calculate the speed of fall in basic magma

Liquid immiscibility D
Shake a jar containing two immiscible liquids before the demonstration. It appears as a single fluid but will separate out into two liquids over a few min if left to stand. Tesco's aromatherapy bath oil works well.

Rhythmic banding Pa P F 15 min
To show the changes in grain size and mineralogy within one rhythmic band students work out the average grain size and percentage dark minerals at the top, middle and bottom in a photo of rhythmic banding.

Crystallisation of olivine Pa I F 15 min
Students plot the temperature of crystallisation against the percentage of Mg and Fe and then answer questions on it.

Crystallisation of acid magma Pa I F 15min
This exercise is to show how the percentage of water in a magma increases as the magma crystallises. Eventually the percentage of water exceeds its solubility in the magma and free water is formed which becomes hydrothermal fluid.

Isostasy

Analogies TE
How does the level of a boat in water change when people get in or out of it?
How does the level of your mattress change as you get into and then out of bed.

Sponge *D*

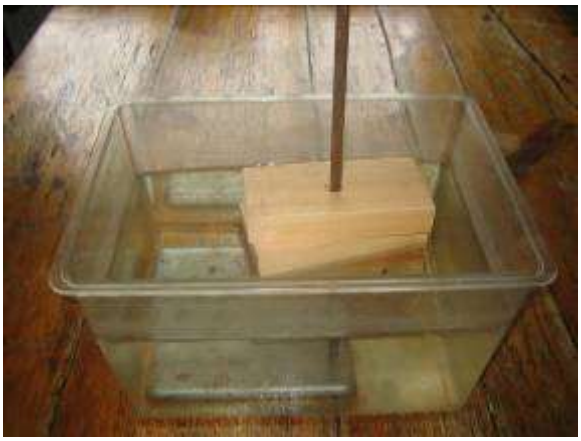
Several different weights are placed on a large piece of very soft sponge 30cm by 30cm by 10cm. which represents the mantle. They sink to different levels just as different sizes of mountains have different depths of roots.

Wood and water *D*

A glass tank is filled with water. A wooden block is put in it and the further blocks of the same size placed on top. The changing level of the top and bottom of the first piece of wood is noted. The pieces of wood are then removed one by one.

Isostasy *E P F 40 min*

As above but students measure the changing levels and the thickness of the blocks of wood added. From their data they work out (or confirm) the formula that relates the changing levels of the surface to the density of the wood and water.



Effects of Isostasy *A or D F 60 min*

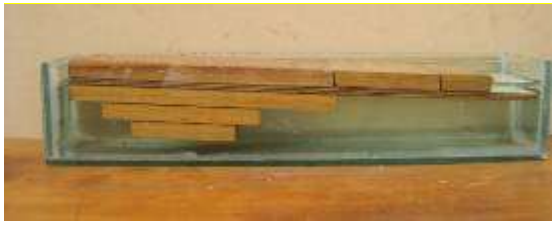
This is a series of activities to show how isostatic adjustment affects the height and shape of the land and the age of the rocks at the surface. This can be run as a circus of activities for students or can be a series of demonstrations. In all activities the crust is represented by blocks of wood and the mantle by the water.

The following are covered:

1 The effect of thickness and of density of the crust on the height of the earth's surface.

2 Explaining why the top of the oceanic crust is lower than the top of the continental crust

3 Explaining the shape of rift valleys
4 The effects of erosion and deposition
5 The effects of ice sheets, volcanoes, and mountain building
6 How isostasy and erosion level explain the age of the rocks at the surface
7 The formation of atolls and guyots



Isostasy and gravity on a volcanic island P 10 min F
Students place a triangle of wood representing a volcano onto a sheet of foam which is floating on water. They work out how the pull of gravity varies over the volcano and surrounding trough. In a second activity they work out how the pull of gravity varies as the volcano sinks due to isostatic adjustment.

Slow sinking D
Use this as demonstration to show that isostatic adjustment is a slow process and that there is a delay between the adding of weight to the crust and the sinking due to isostatic adjustment. A glass sided box 40cm by 10cm by 10cm filled with "memory foam". A heavy weight is placed on top of the foam and it takes 20 min or so to sink. The weight that I use is a triangular shaped piece of lead 9.5cm wide by 9.5cm long by 5cm high made by pouring molten lead into the corner of a wooden box.

The formation of atolls, magnetic model ***D F***

This is a magnetic model. The background is a section showing the air, sea and oceanic crust. A volcano is moved slowly downward as it sinks by isostatic adjustment into the crust and the coral reef is seen to grow upward. Eventually the volcano sinks below sea level and an atoll is formed.