“Hooray and up she rises!” *
How a rising mountain chain can reveal its hidden secrets

As the tops of mountains are eroded away, so the whole mountain range rises gradually to compensate. Deep below the mountains, granite masses have often been intruded as liquid magma and have solidified to coarse-grained solid rock.

Model the way in which such granites may later be exposed at the Earth’s surface. Make up and paint a series of wooden blocks, which are free to slide up and down on a length of stiff wire (Photo 1).

Photo 1: The model before adding water and immersing it into the beaker

Put these in a deep transparent container of water, as shown in Photo 2.

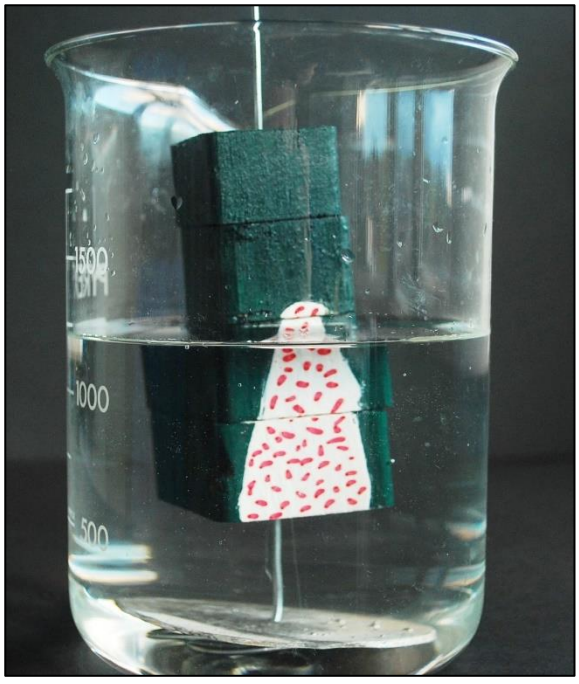

Photo 2: A full set of blocks floating in the water

Explain that the green-coloured part of each block represents older rocks and that the white and pink rock represents a granite mass. This was intruded into the older rocks as liquid magma, but has long since cooled to form granite rock.

Ask pupils to predict what will happen as each block is removed (*A. The remaining blocks will float higher in the water)*.
Ask how many blocks will have to be removed before the granite begins to be exposed on the top of a block? (*A. Two blocks*).
Remove more blocks, as in Photos 3 to 5.

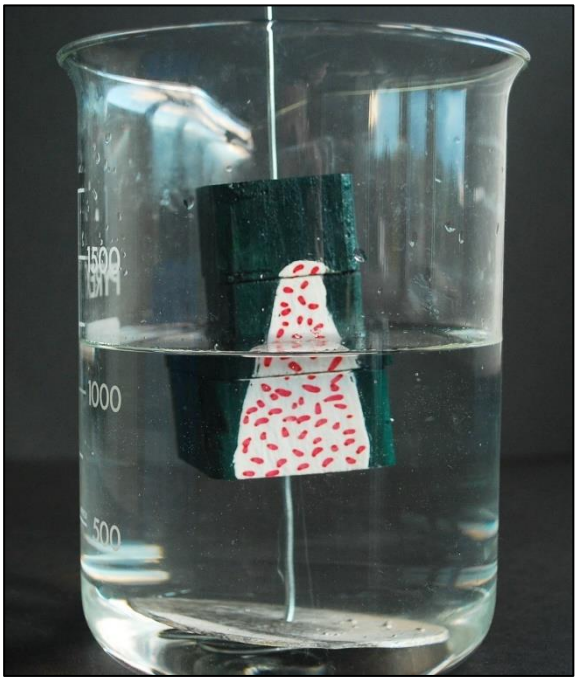

Photo 3: Top block removed

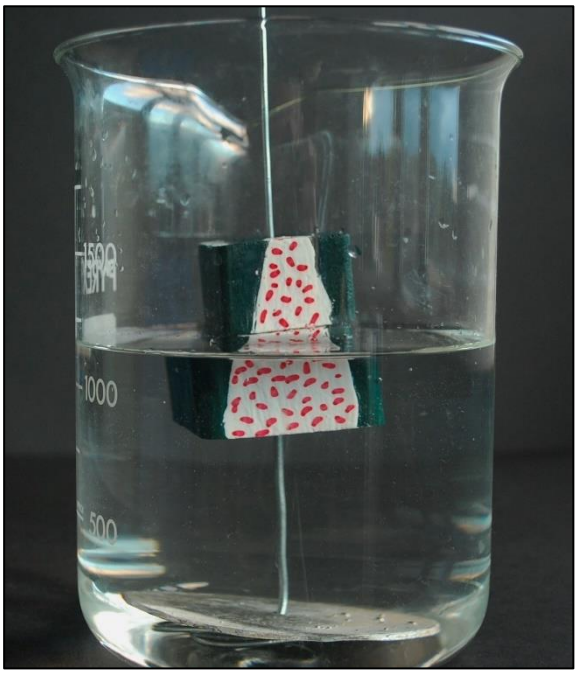

Photo 4: Next block removed, exposing a small outcrop of granite on top of the block

Ask pupils how the width of the granite outcrop changes as more of the intrusion is revealed. (*A, It becomes much wider)*.

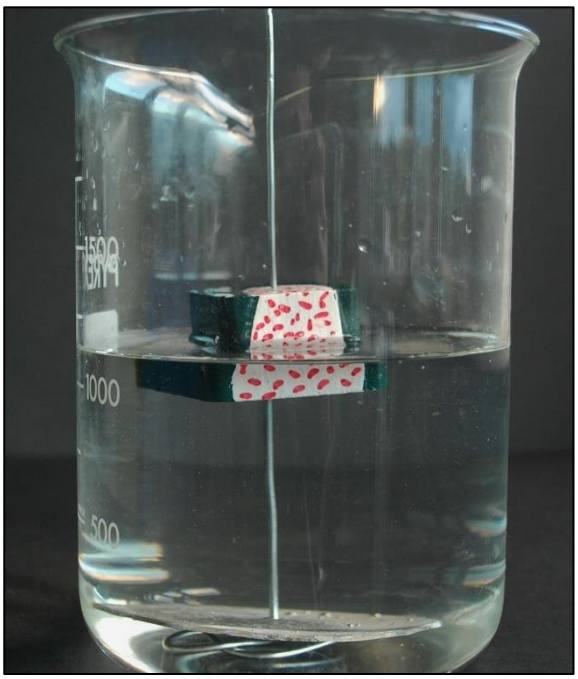

Photo 5: The lowest block remaining, with a wide granite outcrop on its top surface

Photo 6 shows a top view, with two blocks remaining, demonstrating that the granite outcrop becomes much wider.

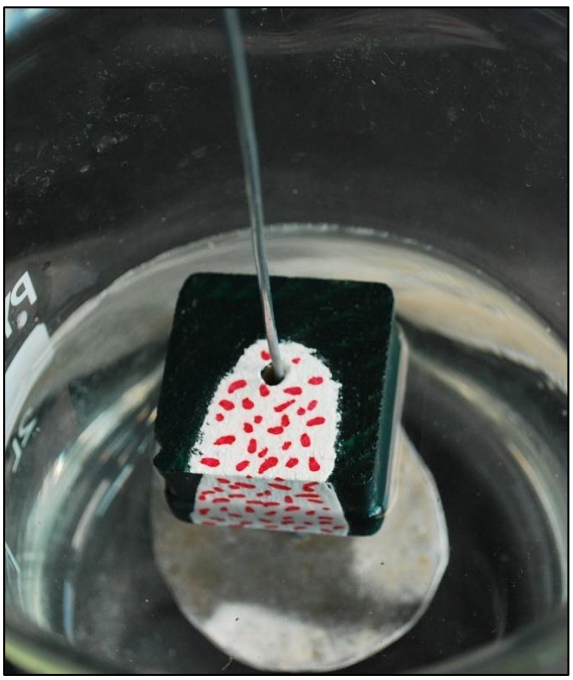

Photo 6: Top view of the lowest two blocks in water, with a wide outcrop of granite
(All photos: *Peter Kennett*)

The back up

Title: 'Hooray and up she rises! (*from the *Drunken Sailor* sea shanty)

Subtitle: How a rising mountain chain can reveal its hidden secrets

Topic: Modelling how erosion of the top of a mountain range is accompanied by isostatic uplift, eventually exposing rocks, once hidden deep below.

Age range of pupils: 11-16 years

Time needed to complete activity: 10 minutes

Pupil learning outcomes: Pupils can:

- explain that a state of balance exists when wooden blocks float in water;
- correctly predict what will happen when floating wooden blocks are gradually removed;
- explain that water flows back under the blocks, to replace the mass of the block which has been removed;
- suggest that the Earth's outer layers (lithosphere) may be in a state of (isostatic) balance;
- relate the model to the changing state of balance in the Earth's lithosphere when erosion reduces the mass of a mountain range;
- understand how a solidified igneous rock may ultimately reach the Earth's surface, even though it is no longer molten.

Context: The activity is aimed at reinforcing the concept of isostasy (a state of balance in the Earth's outer layers). It is also intended to show that many igneous rocks become exposed at the Earth's surface long after they have become solid rocks and are no longer flowing as magma. This activity would have more meaning if preceded by Earthlearningideas: *Isostasy 1: modelling the state of 'balance' of the Earth's outer layers,* and *Isostasy - 2 "Bouncing back" after the ice.*

Following up the activity:
The photographs could be projected in quick succession, to reinforce the sequence of events. Students could study a geological map of an area where granites are exposed at the surface, such as Devon and Cornwall in England (See Useful Links below). They could be asked to predict what they would see if more of the "country rocks" between the separate outcrops of granite were to be eroded away. (*Gravity measurements have shown that the granites of Devon and Cornwall to the Isles of Scilly are linked below ground, forming a huge granite mass, known as a batholith).*

Underlying principles:

- Isostasy is the state of balance which exists in the Earth's outer layers, analogous to hydrostatic balance.
- The outer layers of the Earth together form the lithosphere (i.e. the crust and part of the upper mantle).
- The mantle is mostly solid, but is less rigid than the lithosphere and so can deform

plastically. Given time, it will rebound in response to the removal of a load.
- The very high viscosity of the mantle means that the rebound may take millions of years.

Thinking skill development:
Pupils are challenged to construct a pattern, with the blocks in water, and are then challenged to predict the outcome when the blocks are removed one by one. Relating the modelling to the real world is a bridging skill.

Resource list:
- 4 wooden blocks of the same cross-sectional area, painted to represent a granite mass intruding older rocks, as shown in Photo 1
- a large glass beaker, or equivalent container (the photo shows a 2 litre beaker)
- water
- a length of stiff wire (e.g. from a coat hanger)
- Blu tak™ or fix a piece of sheet lead or similar material to the bottom of the wire to keep the wire vertical in the beaker.

Useful links:
http://www.largeimages.bgs.ac.uk/iip/mapsportal.html?id=1004517 for a “quarter inch” geological map of Devon and Cornwall showing several different granites.
http://www.largeimages.bgs.ac.uk/iip/mapsportal.html?id=1001828 for a 1:50,000 geological map of the Bodmin Moor Granite in Cornwall. The cross-section below the map shows the underground links between the Bodmin Moor Granite and a separate smaller outcrop of granite.

Source: Developed by Peter Kennett from an activity devised by David Turner, Highfield School, Matlock, Derbyshire.