Isostasy - 2
"Bouncing back" after the ice

First make sure that your pupils understand the principle of isostasy, by carrying out the activity *Isostasy -1: modelling the state of 'balance' of the Earth's outer layers*.

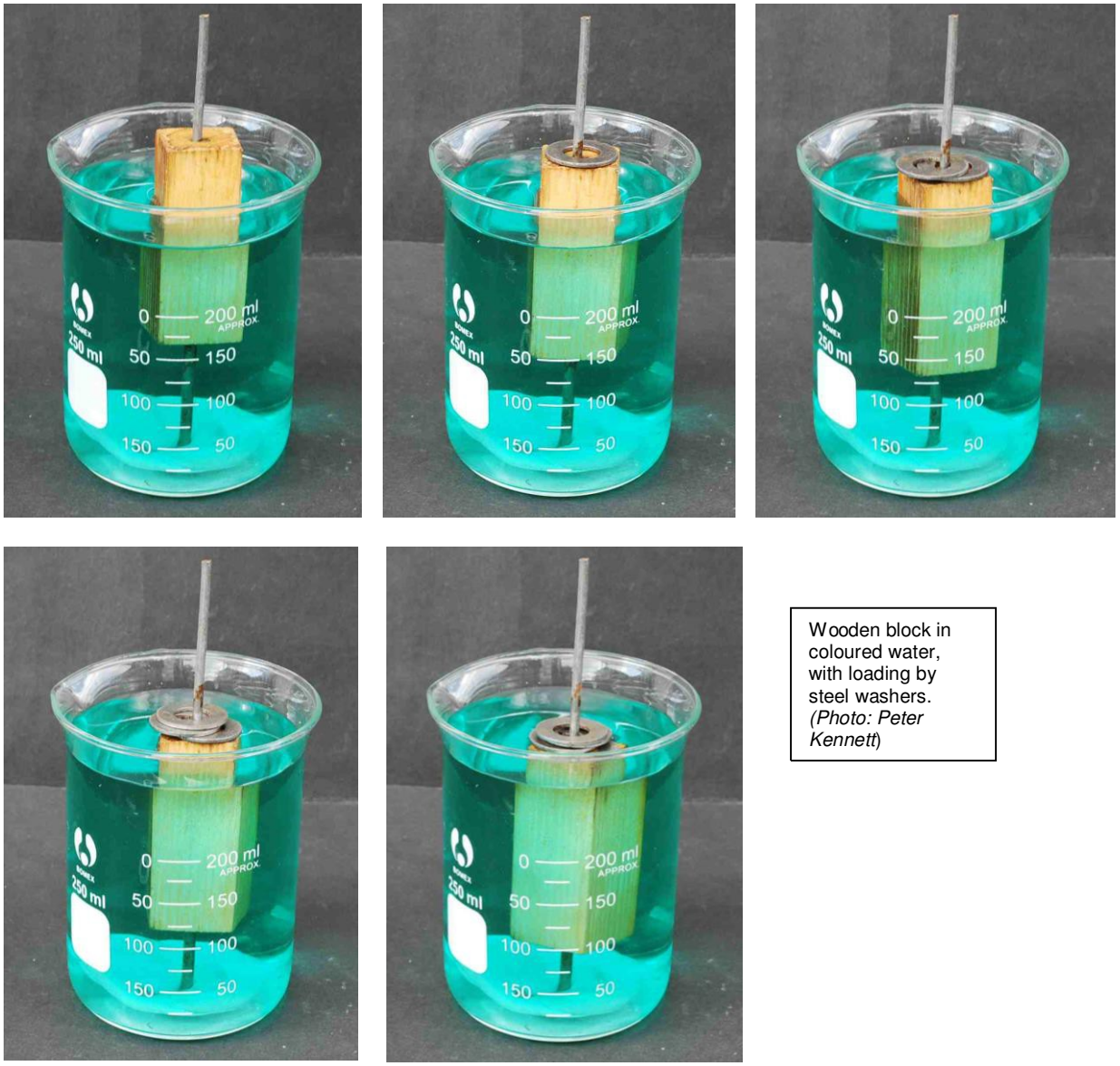
Then use the same apparatus to demonstrate what happens when a large ice sheet forms on a land mass, and then melts away again.

Place a short wooden block onto a wire strut, so that it can slide up and down freely in a beaker of coloured water, as shown in the first picture. Ask what will happen if several identical large washers are placed, one by one, onto the top of the wooden block. Will the extra weight make any difference? Will the block sink more deeply into the water? Will it be the same for each additional washer? Will the block eventually go under the water if enough washers are added? Then carry out the activity as shown in the pictures and discuss the outcome.

Finally, ask what will happen if the washers are removed one by one. In particular, ask the class to say how quickly the wooden block will respond as the washers are removed.

Explain that this model represents what happens to a continent as an ice sheet grows on top of it during an "Ice Age". Removing the washers causes the wooden block to rise, in the same way as the continent 'rebounds' as the ice melts, during an interglacial period.

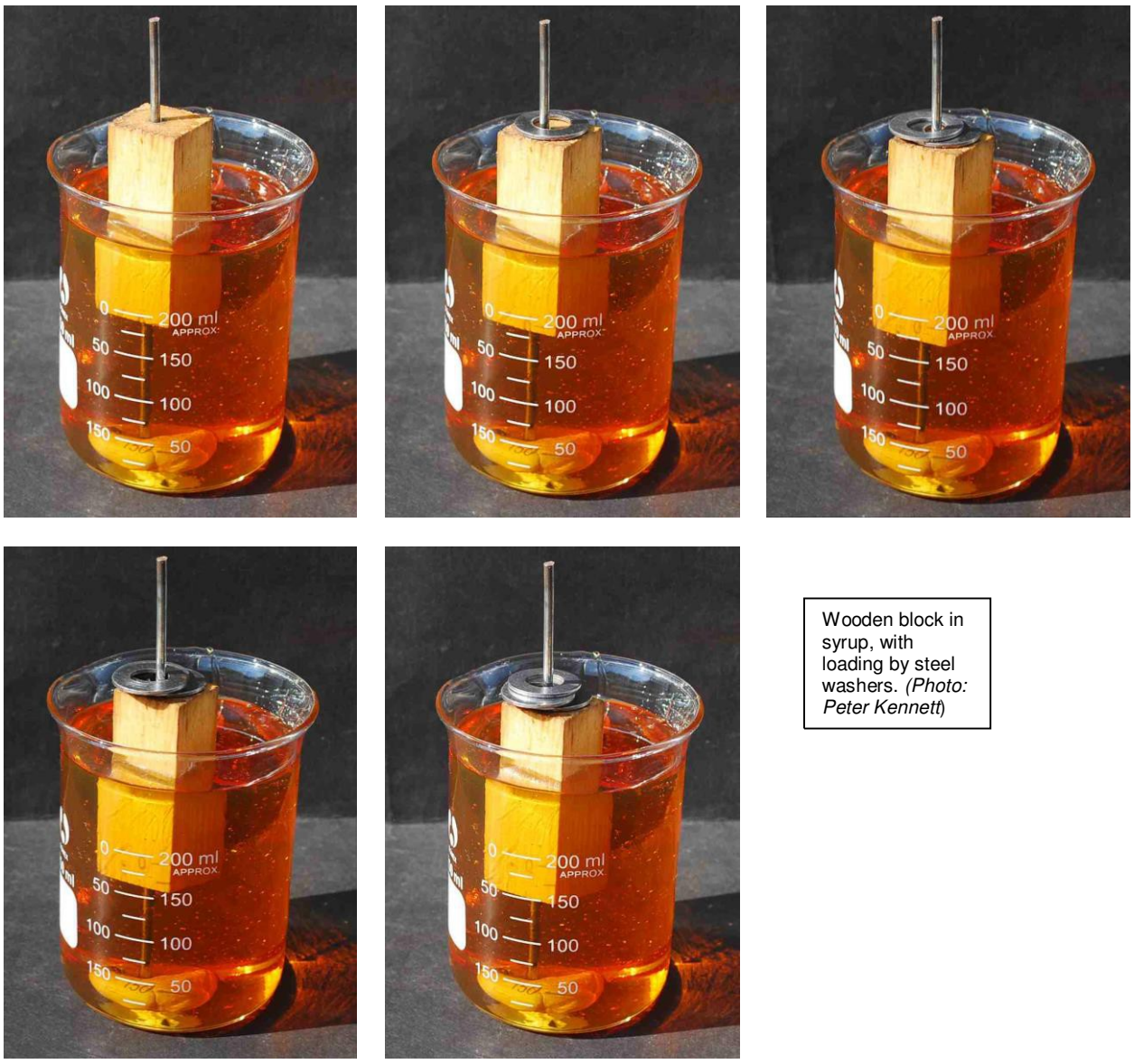
Ask the class to evaluate how closely the model shows the processes affecting the Earth (*The mantle (water) below the lithosphere (wooden block) is <u>not</u> liquid and takes thousands of years to respond to the extra mass of the ice above it (washers), or to its removal by melting).*



Wooden block in coloured water, with loading by steel washers. *(Photo: Peter Kennett*)

To try to show pupils that the mantle is not liquid, repeat the activity, only using a viscous material such as syrup, as shown in the pictures below. Ask the same questions as you did for the first part of the activity. This time, ask pupils to use a stopwatch to measure how long it takes for the block to rebound after each washer is removed, representing the ice melting. (*The rebound is*

much slower than in the first model and can be measured in seconds. This can be linked to the slow rebound of a land mass, responding to flow in the viscous mantle beneath, over thousands of years).



Wooden block in syrup, with loading by steel washers. *(Photo: Peter Kennett*)

The back up

Title: Isostasy - 2

Subtitle: Bouncing back after the ice

Topic: A demonstration of the effects on a continental land mass of an ice sheet growing and then melting.

Age range of pupils: 14 - 18 years

Time needed to complete activity: 20 minutes plus follow up

Pupil learning outcomes: Pupils can:

- explain that a state of balance exists when wooden blocks float in water;
- predict the outcome when a denser medium is used in place of the water;
- relate the model to the changing state of balance in the Earth's lithosphere when additional loading, such as an ice sheet, is added or removed.

Context: The activity can be used in any lesson related to balance in the Earth's lithosphere and in geography lessons dealing with glaciation and its after effects.

Following up the activity:
Show the class the photograph of "Celsius' Rock" on the Baltic coast of Sweden, about 175 km north of Stockholm. Anders Celsius marked the mean sea level in 1731, which is now where the man's hand is holding the 2m tape. Scottish geologist Sir Charles Lyell visited the rock in 1834 and noted that it had risen by 90cm. The current sea level is now about 2m below Celsius' mark, indicating a rise of the land at a rate of about 70cm per century. Several former ports on the Baltic coast are now high and dry as a result of the rise of the land – with detrimental outcomes for their economies.

"Celsius' Rock" (*http://www.sealevelrise.com/?p=213*)

Show the photograph of the Norwegian coast. Much of the landscape is barren rock, which was swept clear of soil and vegetation when Scandinavia was glaciated during the "Ice Age". However, in the last 10,000 years or so, the land has rebounded after the melting of the ice, resulting in raised beaches (beaches with their coastal cliffs that are now above sea level, due to the rising of the land). These provide the only areas where people can settle and make a living.

Ice-moulded rocks (with wind turbines) and raised beach (with housing and farmland), near Stokksund, Norway (Photo: *Peter Kennett*)

Show the map of the British Isles, showing how the north west of the country is gradually rising relative to sea level. Note that the south east is sinking, which is thought to be due to slow outward "flow" of mantle rock beneath that region towards more northerly regions. Ask pupils to discuss the implications, such as an increase in the risk of flooding for London, southern England and southern Ireland.

Map of post-glacial rebound effects upon the land-level of the British Isles. Green = rising, at up to 10cm per century: Orange = stable: Plum = sinking at up to 5 cm per century (*Wikipedia*).

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 can respond to extra loading, or will rebound in response to the removal of that load.
- The very high viscosity of the mantle means that the rebound may take thousands of years longer than the removal of the load, e.g. by melting ice.
- The impact of isostatic rebound on human society, especially those living near coasts in high latitudes, may be profound.

Thinking skill development:

Pupils are challenged to construct a pattern, as metal washers are added to the wooden block in water, and are then challenged to predict the outcome when the syrup is used instead. Relating the modelling to the real world is a bridging skill.

Resource list:

- a short wooden block, with a hole drilled through lengthwise;
- glass beaker, 250ml or larger;
- water, coloured by food dye;
- a length of stiff wire (e.g. from a coat hanger);
- Blu tak™ or similar material to hold down the wire;
- 250 ml of syrup, or similar dense liquid;
- several large steel washers or similar objects
- stopwatch

Useful links: http://en.wikipedia.org/wiki/Post-glacial_rebound

http://www.baltex-research.eu/publications/Books%20and%20articles/The%20Changing%20Level%20of%20the%20Baltic%20Sea.pdf

http://www.sealevelrise.com/?p=213

http://www.earth-science-activities.co.uk/index_htm_files/11-%20EFFECTS%20OF%20ISOSTASY.pdf

Source: Devised by Peter Kennett of the Earthlearningidea Team