Isostasy - 1
Modelling the state of "balance" of the Earth's outer layers

"Isostasy is essentially the principle of hydrostatic equilibrium applied to the Earth" (The Oxford Companion to the Earth, 2000) – otherwise called 'buoyancy'.
Model the principle of isostasy as follows:
Cut two blocks of wood from the same strip, making one block one longer than the other, and drill a hole lengthwise through each block. Fix two pieces of stiff wire to the bottom of a transparent container or beaker, using Blu tak™ or modelling clay. (The wires are to keep the wooden blocks from falling over). Nearly fill the beaker with coloured water and ask the class what will happen to a) the blocks, b) the water level, when the two blocks are fitted freely onto the wires. Then slide the blocks onto the wires and observe what happens (See Figure 1).

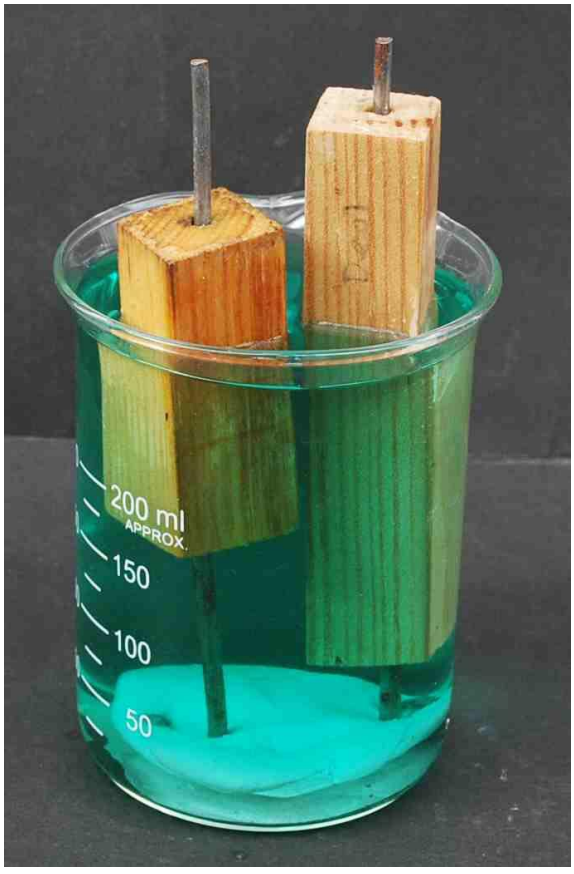

Fig 1. Two wooden blocks of the same cross-sectional area floating in water

Ask the class what differences they might expect if one of the wooden blocks were to be floated in a denser liquid, such as syrup. Would it float at the same depth, at a deeper depth or at a shallower depth? (*shallower, because the wooden block displaces its own mass. The syrup is denser than the water, therefore less of it needs to be displaced*).Then try it out, first filling the beaker with syrup to the same level as the water in the first activity (Figure 2.)

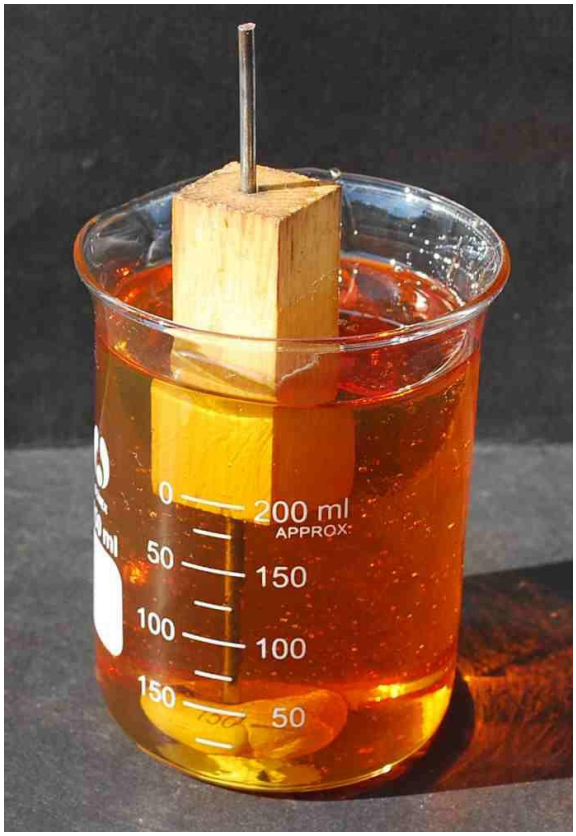

Fig 2. The shorter wooden block floating in syrup (All photos: *Peter Kennett)*

Explain that the model provides a very simplified version of one theory of the Earth, where a state of balance exists in its outer layers. According to the theory, the higher a mountain range rises above the Earth's surface, the deeper is its "root" of lower density rocks beneath. The "root" extends into the mantle. The rocks of the mantle are **not** liquid, but can deform plastically over time to allow the balance to be established. There is good evidence from geophysics supporting this theory. In this activity we use liquids to speed up the process many times! (Figure 3).

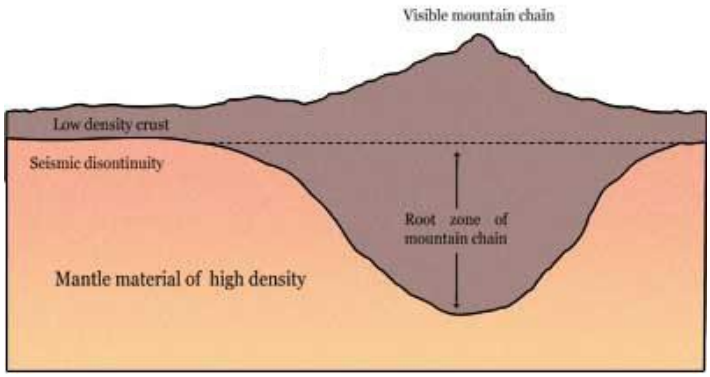

Fig 3. The principle of isostasy applied to the continental crust (from *3.bp.blogspot.com*)

The back up

Title: Isostasy

Subtitle: Modelling the state of "balance" of the Earth's outer layers

Topic: Establishing the principle of isostasy, using wooden blocks floating in water and in a denser medium.

Age range of pupils: 14 -18 years

Time needed to complete activity: 15 minutes

Pupil learning outcomes: Pupils can:
- learn that a state of balance exists when wooden blocks float in water;
- observe that the depth at which the blocks float is proportional to their height;
- understand that the other dimensions of the blocks must be kept constant;
- be encouraged to predict the outcome when a denser medium is used in place of the water;
- relate the model to the state of balance in the Earth's outer layers.

Context: The activity can be used as one means of explaining isostasy, in the context of the Earth's structure and its surface relief.

Following up the activity:
- Make up a more elaborate model, to equate to the diagram in Figure 3. Use a larger tank of water and several wooden blocks of the same density and cross-sectional area, but of varying length (Figure 4, showing these blocks in the tank).
- Model another hypothesis of isostasy, using blocks as shown in Figure 4, (resting on the bench). In this case, the blocks are of woods of different density. They each have the same mass, so that their lengths are inversely proportional to their masses. They float with their bases at approximately the same level, in contrast to the varying depths seen in the activity described on page 1.

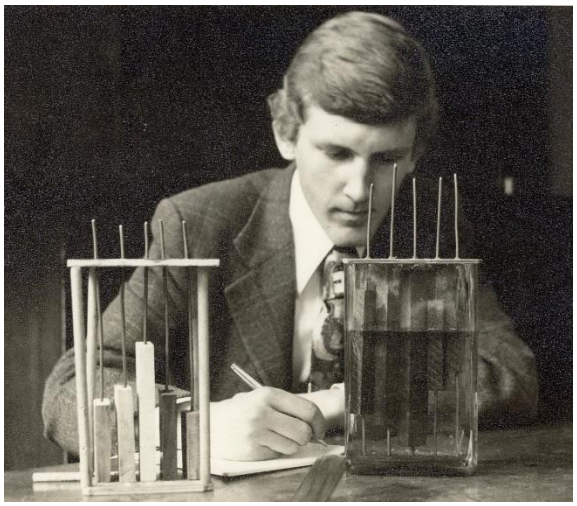

Fig 4. A student trying out different models of isostasy. The blocks in the tank are all of the same density: those on the bench are of different densities

Underlying principles:
- Isostasy is the state of balance which exists in the Earth's outer layers, analogous to hydrostatic balance.
- Two major hypotheses for isostasy were put forward in the 1850s and were later modified.
- The Airey hypothesis proposed the "roots of mountains" model, with low density crustal rocks displacing the denser rocks of the mantle, as shown in Figure 3.
- The Pratt hypothesis proposed that the height of the Earth's surface was compensated for at a constant depth below sea level, modelled by crustal blocks of different density.
- Airey's model is now known to be more realistic in most circumstances.
- It is now also appreciated that the outer layers of the Earth should be taken to be the lithosphere (i.e. the crust and part of the upper mantle together) and not simply the crust alone.

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 syrup is used. Relating the modelling to the real world is a bridging skill.

Resource list:
- 2 wooden blocks of the same cross-sectional area (e.g. 2cm square), but of different length;
- glass beaker, 250ml or larger;
- water, coloured by food dye;
- 2 lengths of stiff wire (e.g. from a coat hanger);
- Blu tak™ or similar material to hold down wires;
- 250 ml of syrup, or similar dense liquid;
- (Optional, for follow up) – sets of wooden blocks and wires (one set of blocks of the same material, the other of blocks of different densities) a means of holding down the wires; a larger tank, all as shown in Figure 4.

Useful links:
For a wide range of activities, on isostasy, using a standard tank
http://www.earth-science-activities.co.uk/index_htm_files/11-%20EFFECTS%20OF%20ISOSTASY.pdf

http://3.bp.blogspot.com/_m4XPMo4ibp8/SjSAm5ytFxI/AAAAAAAAAUw/tvoGnLhQVgw/s1600-h/g_mountain_root.jpg for picture of mountain roots.

Source: Devised by Peter Kennett of the Earthlearningidea Team in the form shown in Figure 4 and then adapted.