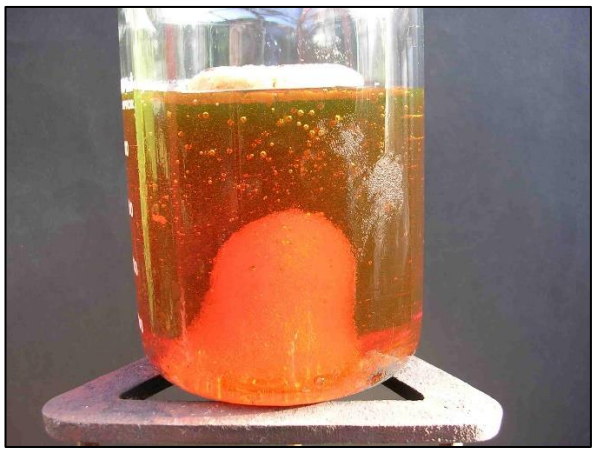
A "mantle plume" in a beaker – but not driving plates
Mantle plumes 'yes' – but convection currents driving plates, probably 'No'

Modeling a mantle plume
We can model a mantle plume in a beaker. Take a 600 ml beaker of Golden Syrup™ which has been placed in a freezer for about one hour, so that its viscosity has been increased (i.e. it is much less runny than at room temperature). Place the beaker on a tripod (without a gauze) and heat over a Bunsen burner (cautiously, at first). Ask the students to predict what will happen as the syrup heats up, and then to watch carefully from the side.

As the syrup warms, it becomes paler in colour and a "plume" of warm syrup begins to rise towards the surface. Gradually, the plume widens, reaches the surface, and then spreads out sideways in the way that plumes of hot but solid flowing mantle material probably do. See the photo below and the photo sequence on page 3 of this Earthlearningidea. [Note: a rising plume can be seen even in syrup at room temperature, but not so clearly].

Mantle plumes are thought to cause long term volcanicity and to produce huge amounts of volcanic material, such as the rocks making up the island of Iceland, the Hawaiian Islands and the Deccan Traps of India.



A plume of hot syrup in a 600 ml beaker

Modelling plate tectonic movement?
If you break a biscuit into two halves and place these together on top of the syrup before you start to heat it, they are gradually moved apart by the rising mantle plume as convection currents begin to form in the beaker as in the photo opposite and the second photo sequence on page 3. When scientists thought that it was convection currents in the mantle that carried plates and caused plate tectonic movement (the mantle drag mechanism – described in the *"All models are wrong' – but some are really wrong: plate-driving mechanisms'* Earthlearningidea) – this was thought to be an excellent model of how diverging plates were driven apart.

Not moving plates!

The recent evidence
However, as described in the *"All models are wrong' – but some are really wrong: plate-driving mechanisms'* Earthlearningidea:

Most recent evidence shows that:
- slab pull is the main plate-driving mechanism;
- ridge push can have an effect where slab pull is not the main plate driver;
- there is little or no evidence that convection currents in the mantle move plates (apart maybe from some very small plates in unusual circumstances).

Part of this recent evidence comes from the idea that, if the convection current mantle drag mechanism was the main driving force of plate movement, then we would expect the largest plates, with the largest areas on which the mantle could drag, to be the fastest-moving plates. They are not. Instead, the fastest-moving plates are those with the longest subduction zones, showing that the slab-pull mechanism is likely to be the main plate-driving force (see the *'What drives the plates?'* Earthlearningidea for more details).

When answers that seem 'right' are 'wrong'
This discussion shows that when scientists have suggested a likely explanation for a scientific observation, and particularly when such an explanation can be modelled beautifully in the lab, it is likely to be attractive to many people – and may even be taught as the 'right answer'. It is only when scientists seek and find more evidence, that such 'right' answers are shown to be partly or completely 'wrong'.

So, when you see diagrams or descriptions in textbooks of convection currents carrying plates – beware! They are almost certainly wrong.

Note: This Earthlearningidea replaces the *'A "mantle plume" in a beaker: modelling processes at a constructive (divergent) plate margin'* Earthlearningidea, which was published when the convection current model of mantle drag was thought to be the main driving force of plate movement.

The back up

Title: A "mantle plume" in a beaker – but not driving plates.

Subtitle: Mantle plumes 'yes' – but convection currents driving plates, probably 'No'.

Topic: Investigating what happens when a viscous material (Golden Syrup™) is heated and rises, modelling a mantle plume (but not modelling how convection currents can drive plate movement).

Age range of pupils: 12 – 18 years

Time needed to complete activity: 15 minutes to run the actual activity **or** 5 minutes to watch and discuss the sequence of photographs.

Pupil learning outcomes: Pupils can:
- make predictions based on their previous experience of heating materials;
- explain how the vertical flow of a viscous medium can cause lateral movement of the floating objects above;
- describe how the model seems to be like a plate-driving mechanism, but how more recent evidence has shown this not to be so.

Context: The activity can be used during the course of both science and geography lessons to illustrate how models which were once thought to show how Earth processes work can be misleading.

Following up the activity:
Try the Earthlearningideas which focus on the recent evidence for plate-driving mechanisms: *"'All models are wrong' – but some are really wrong: plate-driving mechanisms: many textbook diagrams of plate-driving forces have arrows in the wrong places'*; *'What drives the plates? Using a pupil model to demonstrate that slab pull is the main plate-driving force'* and *'What do the top and bottom of a tectonic plate look like? Questions to test understanding of plate tectonic processes'.*

Underlying principles:
- Parts of the mantle have high heat flow resulting in mantle plumes.
- Mantle plumes can cause long-term volcanicity and huge volumes of volcanic materials.
- This model shows how a convection current can move solid materials apart – but this 'mantle drag mechanism' is not now thought to be a major plate-driving process
- The main plate-driving process is now thought to be the 'slab-pull mechanism', with the 'ridge-push mechanism' having effects on some plates.

Thinking skill development:
Relating the model to the real world is a bridging activity. The discussion outlined above shows how scientific thinking can develop on the basis of new evidence.

Resource list:
- 600ml heat-proof glass beaker
- about 900g of Golden Syrup™ or similar syrup
- Bunsen burner with gas supply (**or** camping gas stove), tripod, heat proof mat, matches
- a biscuit

OR
- photographs from this activity (see page 3), transferred to a computer, using slide show software e.g. Microsoft PowerPoint, OpenOffice Presentation or a video
- data projector

Useful links:
https://www.earthlearningidea.com/PDF/326_Plate_driving_mechanisms.pdf
https://www.earthlearningidea.com/PDF/217_Slab_pull.pdf
https://www.earthlearningidea.com/PDF/333_Top_bottom_plates
For two recent updates, see also:
https://www.earthlearningidea.com/PDF/333_Update_Joides.pdf
https://www.earthlearningidea.com/PDF/333_Update_plate_tectonics.pdf

Source: This activity was originally published as the **'***Mantle convection moving plates: the golden syrup / hobnob teacher demonstration*' as part of the Joint Earth Science Education Initiative (JESEI) that has 40 other Earth science activities published on the JESEI website: http://www.esta-uk.net/jesei/index.htm

See Page 3 for photographs of the activity

Successive side views of the plume of hot syrup rising through the mass of colder syrup

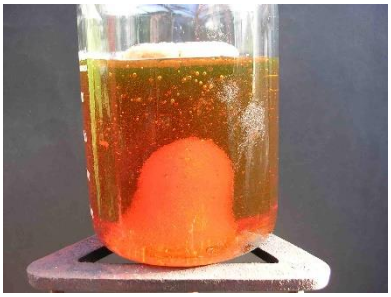

1. Before heating starts


2. The plume begins to form


3.


4.


5.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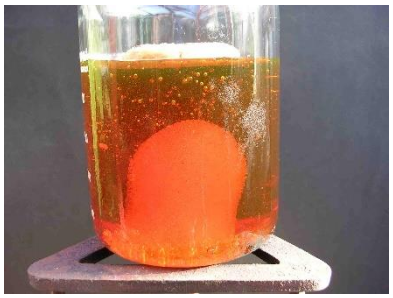
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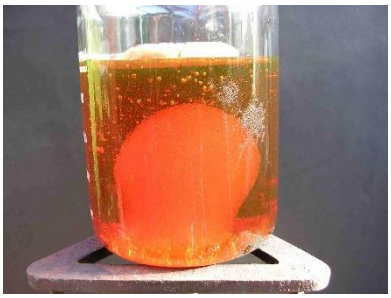
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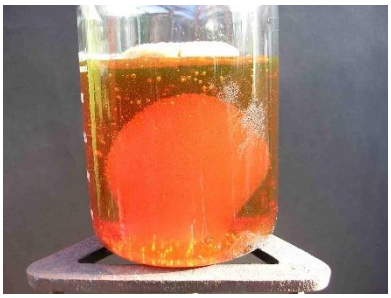
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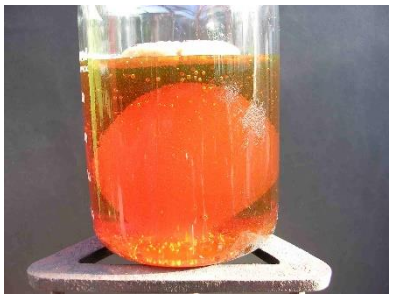
10.


11.

The broken biscuit being moved apart above the rising plume – this is now thought not to be the main plate-driving mechanism


1.


2.


3.

All photographs – Peter Kennett.