SCIENCE

Lesson 3

Year 9

Topic: Investigating tectonic processes

Understanding the role of heat

Today you will:

- describe the Earth's structure and the process and that drive tectonic plate movements.

Resources

Digital

Video — Syrup mantle (4:56)

Key terms

asthenosphere, convection, crust, inner core, lithosphere, mantle, outer core, tectonic plate

For definitions and explanations of terms, please see the Glossary.

Science start-up

Review Earth's structure

In Year 8 you would have studied the basic structure of Earth to understand the formation of rocks. In this lesson you will build on what you already know of Earth's structure to understand plate tectonic processes.

1. Go to the **Website — The structure of the Earth (BGS)** https://www.bgs.ac.uk/discoveringGeology/hazards/earthquakes/structureOfEarth.html. Read the information about each layer that makes up Earth's structure and how measuring seismic waves helps scientists describe the internal structure of Earth.
   a. List the four main layers of Earth.

   b. How do we know that the core is composed of a solid inner part and a liquid outer part? Be specific about the wave types and the way they travel.

c. Parts of the mantle layer are described as being 'plastic'. What feature/s of the mantle would lead scientists to use this terminology?

d. What do you think the fluid and plastic layers of Earth have to do with plate tectonic theory?

During this lesson, you will learn about and view a model of one of the forces which move tectonic plates across the surface of Earth.

Lesson

Model the role of heat in plate movements

In the sketch (right) the fluid at the bottom of the beaker, directly above the bunsen, is heated and expands, becoming less dense. This less-dense fluid rises, becomes more dense as it cools and sinks again. As this process continues, a circular current is formed.



Sketch showing convection cells commonly seen in boiling water or soup (U.S. Geological Survey), http://pubs.usgs.gov/gip/dynamic/unanswered.htm

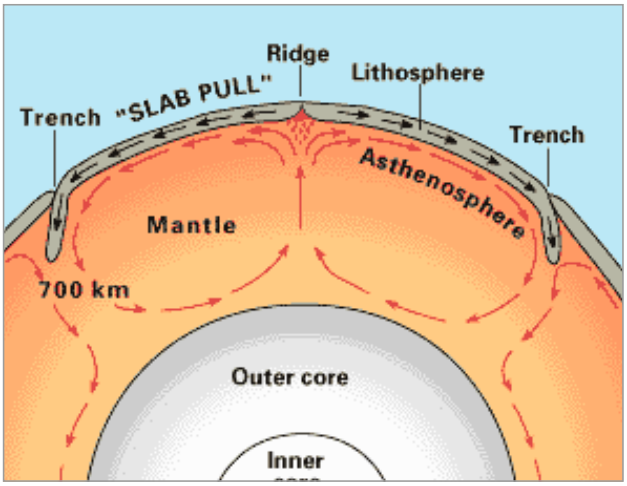
Density is a measure of the amount of mass per unit volume. As heat is applied, particles move apart and the material occupies more volume, which reduces density. Less dense materials float or are buoyed upwards.

Just as convection currents move through the air or a body of liquid being heated in a beaker, convection currents form in Earth's mantle.

Parts of the lower mantle, in contact with the hot outer core, are heated, then soften and flow very slowly. This heated, less-dense material rises up through the lower mantle until it hits the more solid rock of the upper mantle. It then moves sideways, becomes more dense as it cools, and sinks again, forming a convection current in the lower mantle.

This drawing shows a representation of convection currents formed in the lower mantle. The sideways movement of heated mantle material under the lithosphere (upper mantle and crust) causes the 'slab pull' (labelled in the drawing), which in turn causes tectonic plates to move. Each plate moves in a direction dictated by the motion of the lower mantle material.

It should be noted that while convection currents in the lower mantle do have an effect, scientists now believe the gravitational force of one tectonic plate sinking below another is a greater influence on plate movements.



Conceptual drawing of assumed convection cells in the mantle (U.S. Geological Survey), http://pubs.usgs.gov/gip/dynamic/unanswered.html

The **lithosphere** is a rigid layer of the Earth formed by the upper mantle and the crust, about 75 km thick. There is not a clear boundary between solid rock and plastic rock but earthquake waves move considerably slower through the more plastic **asthenosphere** layer about 75–200 km deep. Convection moves the asthenosphere which pulls the solid tectonic plates making them move, thus allowing the plates of lithosphere to 'float' on top.

2. Go to the **Website — US Geological Survey 'Some unanswered questions'** https://pubs.usgs.gov/gip/dynamic/unanswered.html. This website gives a more in-depth explanation on what drives the movement of tectonic plates.

Tectonic plate modelling

Geologists create models to study and visualise what might occur. The CSIRO programmed a computer with forces and processes involved in mantle convection, as well as evidence of sedimentary rock and fossils which indicated that the sea covered much of Australia. The computer processed the information to model the movement of the Australian tectonic plate.

3. Go to the **Website — European Space Agency** and search for *GOCE reveals Antarctic tectonics.* https://www.esa.int/esearch?q=tectonic+plate+shifts.
   a. Which other land mass did Australia break away from and over what period did this occur?

b. What aspects of Australia are explained by this computer model?

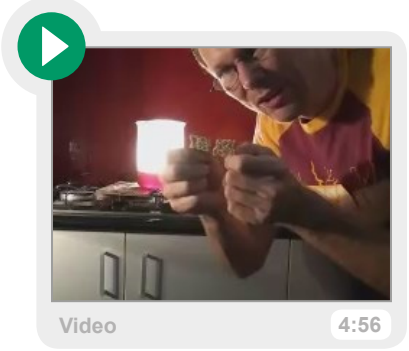
c. What caused Australia to be lower and by how much did it move downwards?

d. Which direction did the Australian Plate move and what prevented the land from being flooded when sea levels rose?

e. What evidence do you think led researchers to believe that Australia was once covered by an inland sea?

Scientists use models, such as experimental models where materials are used to simulate a situation. Here syrup is used for the mantle and a thin biscuit for the crust. Heat is provided to the mantle in a narrow strip just like along a mid-ocean ridge.

4. Watch the **Video — Syrup mantle** to see this model in action.



5. Syrup mantle questions:

   a. How does placing the syrup in the freezer before it is heated simulate conditions in Earth's lower mantle?

   b. Are a thin biscuit and deep syrup a good representation of the crust and mantle? Justify your answer.

   c. In what ways does the syrup model represent plate tectonic processes?

Reflection

A labelled diagram or drawing is a visual representation used to illustrate the shape, size and external features of an object. It includes labels of the main observable features.

An annotated diagram or drawing is a visual representation used to illustrate an idea, object or concept. It includes comments and observations to describe the object or concept.



6. Draw an annotated diagram in your Science journal to show and explain the different processes that drive the movement of Earth's tectonic plates. Refer back to all the resources in this lesson to assist with your diagram and annotations.