UNIVERSITY OF CAMBRIDGE
VOLCANO SEISMOLOGY

OCR
Oxford Cambridge and RSA

EXPERIMENTS ON EARTHQUAKES AND VOLCANOES

EXPLOSIVEEARTH

EXPERIMENTS

The earth is an exciting, explosive place... find out a bit more about how earthquakes and volcanoes work with these fun experiments.

Try it with friends:

BUBBLE ESCAPE AND DRAG RACE
Viscosity and Violent Volcanoes

There are many different types of volcanoes. Shield volcanoes have a broad rounded shape and gentle splattery eruptions often described as fire fountains. Strato volcanoes are sharp and steep sided in shape and have violent explosive eruptions. But what makes these two types of volcano look and erupt so differently? It is mainly controlled by how thick (viscous) or runny the magma in the volcano is…

In this experiment you can you use 3 fluids of different viscosity (thickness) to see what differences runny or thick magma can cause in volcanoes. This experiment can get a bit messy, so make sure you do it somewhere easy to clear up.

What you'll need:

- 3 plastic straws
- A chopping board or tray
- 50ml water (very runny fluid)
- 50ml honey (mid range viscosity fluid)
- 50ml golden syrup (very thick viscous fluid)
- 3 small clear containers (shot glasses/plastic cups)

Instructions

1 - **Gas Escape**

Put each of your liquids into a container. Take your straw and blow bubbles into each of the liquids.

Is it easier to blow into the thick viscous golden syrup or the runny fluid water? What does it look like when you blow into each liquid?

What if these fluids were actually magma… is it easier for gas to escape from thick viscous magma or runny magma? What would this mean for the style of the eruption?

What's happening?

The thick viscous golden syrup is very hard to blow bubbles in, while the runny water is very easy to blow bubbles in and very splattery. This means that when gases come out of magma they find if much harder to escape from thick viscous magma than runny magma. When the gas can't easily escape from viscous magma, pressure builds up causing explosive eruptions. Gas easily escapes from runny fluid magma causing splattery non-explosive (effusive) eruptions.

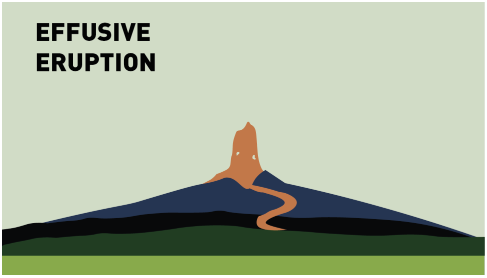
Instructions

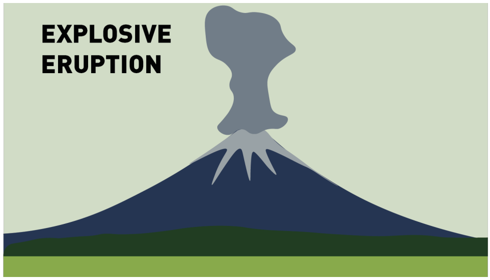
2. Viscous Vs. Runny Race

Take your chopping board and hold it at a steep angle. Take each of your fluids and pour them down the slope timing how long they take to get to the bottom.
Which fluid was fastest? The thick viscous golden syrup or the runny fluid water? What if these fluids were actually lava? As hot lava cools it solidifies and turns into solid rock. How far would a viscous or runny lava get before if cooled down and turned to rock? What would this mean for the shape of the volcano it formed?

What's happening?

The thick viscous golden syrup runs down the slope very slowly, while the runny fluid water runs down very quickly. If this were lava erupted from a volcano, this means that viscous lava couldn't travel very far from the vent before cooling and solidifying, whereas runny lava can go long distances before cooling. This means that volcanoes with runny lava can create broad shallow sloping volcanoes, whereas volcanoes with thick lava quickly build up steep sides.





FACT

Splattery non-explosive volcanic eruptions are called EFFUSIVE.
The scientific word for how runny or thick a fluid is, is VISCOUS. Thick fluids like golden syrup have a high viscosity and runny fluids like water have a low viscosity.

KEY POINTS

- Fluid runny lava, lets gas escape easily so creates splattery non-explosive (effusive) eruptions. Runny lava can travel a long way from the vent before cooling, so forms broad shallowly sloping volcanoes. Shield volcanoes are an example of this.
- Viscous lava traps gas, allowing pressure to build up until a violent explosive eruption happens. Viscous lava can't travel far from the vent before cooling, forming sharp steep sided volcanoes. Strato volcanoes are an example of this.

INFO FOR INTERESTED ADULTS

What makes magma runny or viscous?

VINEGAR VOLCANO
Escaping Gas and Eruptions

Volcanoes form when hot molten rock (magma) under the ground erupts at the surface, but what causes the molten rock to erupt? Eruptions are often driven by gases escaping...

In this experiment you can start a chemical reaction that creates a gas, and see how the gas escaping drives an eruption.

What you'll need:

- A 1L plastic drinks bottle (eg tonic)
- A pair of scissors
- A few tsps bicarbonate of soda
- A splash of vinegar
- Centre-page volcano cut-out
- Bluetack

Instructions

1. **Create your volcanic cone**

Ask an adult to cut the plastic bottle in half, 15cm below the lid, and then to cut off the top of the bottle 5cm below the lid, as in the photo above. Turn the lid piece upside down and place into the top of the bottle.

2. **Decorate your volcano**

Cut out the volcano outline in the centre of this booklet and decorate it. Fold it into a cone and secure it with tape/glue. Position it inside your bottle and seal the top with bluetack to protect your artwork!

3. **Start the eruption!**

Load the bottle lid with bicarbonate of soda. Then you're ready to quickly pour in a big splash of vinegar and watch what happens!

What's happening?

When the vinegar and bicarbonate of soda come into contact a chemical reaction takes place, producing a gas. The gas is much less dense that the surrounding liquid so it tries to escape upwards carrying lots of the liquid with it, forming the bubbly fizzing eruption you see.

This is very similar to what happens in a volcano when escaping gases try to rise up and out...they take the molten rock with them, resulting in a volcanic eruption!

KEY POINTS

Volcanic eruptions are often driven by gases trying to escape

INFO FOR INTERESTED ADULTS

What happens if molten rock is erupted under a glacier?

COKE VOLCANO
Dissolved Gas in Magma

When molten rock (magma) is underground it often has lots of gases dissolved in it, just like liquid coke is full of dissolved carbon dioxide gas. As magma rises closer to the surface the gas starts to escape (exsolve) from the magma, but what happens then?

In this experiment you can use coke to represent magma under a volcano and see what happens when all the dissolved gas is released!

What you'll need:

- A bottle of fizzy drink (diet coke is good as it's less sticky, but any fizzy drink will do)
- A pack of mentos mints

Instructions

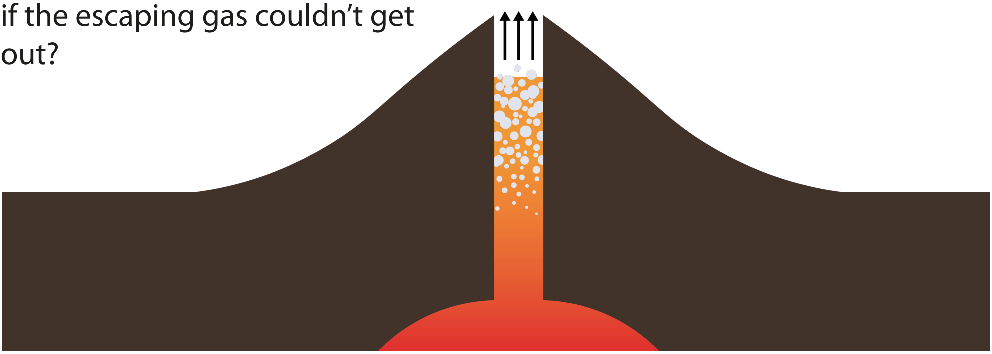
Place your bottle of fizzy drink somewhere you don't mind getting wet (outside is good)!
Roll a scrap of paper into a mentos-sized tube and fill it with 3-4 mentos.
Take of the lid of the bottle and quickly pour in the mentos! Jump back to avoid getting sprayed!

What's happening?

Dropping a mentos into your coke releases the gas dissolved in it. Gas is much less dense than liquid so all the gas bubbles rise to the top of the bottle and escape, taking some of the liquid with them.

This is exactly the same as what happens in a volcano. When the gas comes out of the magma, it tries to escape upwards taking some of the magma with it, forming a volcanic eruption!

What do you think would happen if the escaping gas couldn't get out?



When dissolved gas comes out of a liquid it's called EXSOLVING

KEY POINTS

- Volcanic eruptions are driven by gas dissolved in the magma escaping and moving upwards

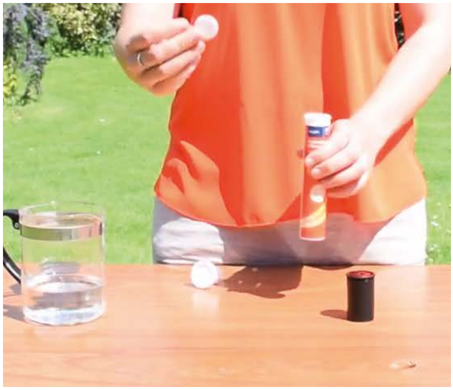
INFO FOR INTERESTED ADULTS

What are the gases that are dissolved in magma?

EXPLODING CANISTER
Trapped Gas and Explosive Eruptions

Volcanic eruptions are driven by gas dissolved in molten rock (magma) underground trying to escape upwards. But what happens if the gas gets trapped and can't get out?

In this experiment you can trap more and more gas in a sealed container, in the same way gas can get trapped in a volcano, and see what happens…



What you'll need:

- An old film canister
- Fizzy dissolving tablets (such as vitamin/antacid tablets)

Instructions

Find somewhere to do your experiment you don't mind getting wet. Fill your canister half full with water. Then, as quickly as possible, drop in a quarter of a fizzy tablet, put the canister lid firmly back on and step backwards to watch what happens!

What's happening?

When you add the dissolving tablet it reacts with the water and fizzes, producing gas bubbles. Since the lid is on, the gas can't escape, so pressure builds up and up as more gas is formed. When the pressure in the canister is high enough the lid is forced to pop off!

In volcanoes this can happen too. When gas can't escape pressure builds up until there is a violent explosive eruption! Gas often gets trapped when the magma is really thick (viscous) instead of runny, and can block the way out forming a magma plug (like the lid on top of the canister).

Image: USGS

FACT

When molten rock is underground it is called MAGMA, once it is erupted on the surface it is called LAVA

KEY POINTS

- Volcanoes erupt due to gases being released
- Volcanoes with thick viscous magma trap gas
- If the gas gets trapped, pressure builds up, and this causes an explosive eruption!

INFO FOR INTERESTED ADULTS

What is a volcanic plug?

ERUPTION IN A FISH TANK
Rising Eruptive Plumes

When there is an explosive volcanic eruption a large amount of material is thrown up into the air in an eruptive plume or column, made up of tiny rock fragments and very hot gases. The material is initially thrown upwards by the force of the explosion, but it keeps rising and stays airbourne for a long time… so what stops it falling down?

In this experiment you can create your own eruptive column in a fishtank and find out what it is that makes it rise…

What you'll need:

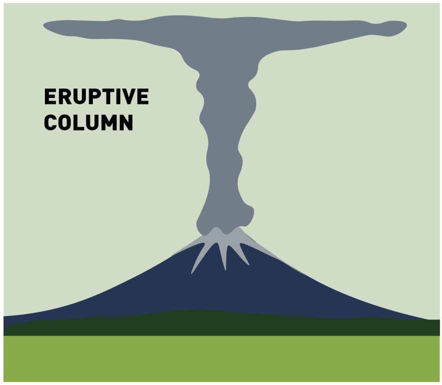
- A large clear container that can hold minimum 20cm deep water (a fish tank works best)
- A small empty glass bottle (food coloring bottles are perfect)
- A drop of red food colouring
- A kettle

Instructions

Fill your large container to the top with cold water. Ask an adult to put a drop of red food coloring into the small glass bottle (not too much or it won't work), and top it up with water from a just boiled kettle (right to the top). Then instruct your adult to place the small bottle at the bottom of the tank of cold water in the middle. Stand back and watch what happens…

What's happening?

The red water in the bottle should rise upwards forming an eruptive plume column. This happens because the red water is much hotter and therefore less dense than the water in the tank. Because it is less dense it rises up towards the top of the tank, a process known as convective upwelling. This is exactly what happens in a volcanic eruptive column. Initially, all the material is thrown upwards by the force of the explosive eruption, but after this it continues to rise, instead of falling straight back down. This is because the hot gases are less dense than the surrounding air and so rise up, taking tiny fragments of rock with them.



If you leave the experiment for long enough, you may see the red eruptive column start to sink back towards the bottom of the tank as it cools down and becomes more dense. When this happens in the eruptive column, the hot gases drop all the tiny rock fragments they are carrying, forming volcanic ash fall.

KEY POINTS

- Eruptive columns are made from material thrown in the air by an explosive eruption.
- The reason they continue to rise is because the hot gases are less dense than the surrounding air.

INFO FOR INTERESTED ADULTS

How is ash formed?

WONDERFULLY WAXY VOLCANO IN A CUP

Igneous Intrusions

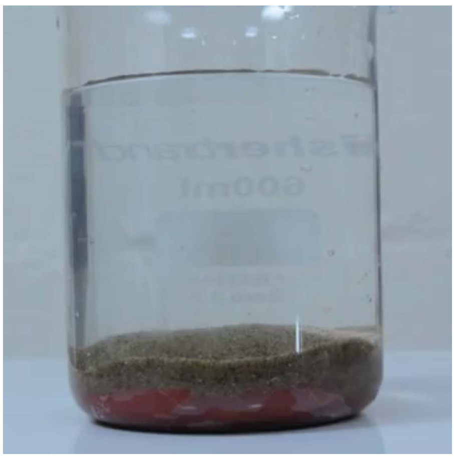
Hot magma beneath a volcano always wants to move up towards the surface. This is because it is a hot liquid and is less dense than the surrounding rock and so rises upwards. But as magma rises it cools and eventually turns into solid rock…

In this experiment you will see what happens when melted wax moves through layers of sand and water, just like magma moves though layers of rock to reach the earth's surface.

What you'll need:

- A chunk of candle wax (red looks the best, but any colour will do)
- A handful of sand
- A clear 500ml volume glass container (a mug, jug or beaker may work well)
- A hotplate/Bunsen burner as a heat source
- An adult who can handle the heat

Instructions



Ask your adult to melt the candle wax into the bottom of the beaker to make a 1cm thick layer at the bottom, then let it cool and set. Once the wax layer is solid cover it with a layer of sand about 1 cm thick. Finally top your beaker up with very cold water (or chill in the fridge for 15 minutes) until it is about ¾ full. Now place your beaker on your heat source and turn to a medium-high temperature, wait, watch and see what happens...

What's happening?

When you warm up the beaker the solid wax is heated up and melts. The molten wax is less dense than the sand and water, so it travels upwards towards the surface. But as it rises the cold water cools the wax down and it solidifies in the water layer, sometimes it reaches the surface of the water and spreads out on top, sometimes it doesn't.

This happens in volcanoes too. As magma rises through the earth's crust it cools down. Sometimes, if it cools enough, it doesn't reach the surface at all and there is no eruption. Instead it solidifies. This is called an igneous intrusion.

KEY POINTS

- Molten rock (magma) underground is hotter and less dense than the surrounding rock so moves upwards.
- Sometimes magma doesn't reach the surface to make an eruption, but cools down and solidifies inside the earth's crust, forming an igneous intrusion.

INFO FOR INTERESTED ADULTS

What types of igneous intrusions are there?

SHAKY STRUCTURES
Earthquake Resistant Buildings

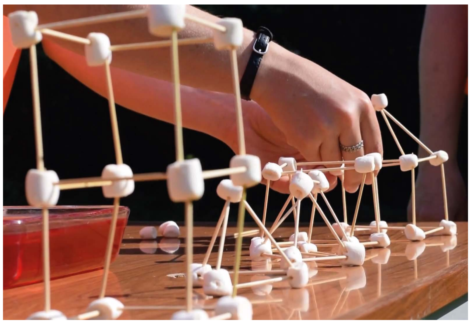
When an earthquake occurs near a town or city it can cause lots of damage. In areas where there are lots of earthquakes, engineers must design earthquake-proof buildings which sway with the motion of the earthquake, rather than cracking and breaking. But what kind of structures do you think make good earthquake-proof buildings?

In this experiment you can make some earthquake-proof buildings of your own, using cocktail sticks and marshmallows. Give them a shake on some wobbly jelly to simulate an earthquake, and see how well they hold up!

What you'll need:

- A deep pyrex dish or baking tray approximately A4 size
- A pack of jelly
- Some cocktail sticks
- A bag of mini marshmallows (fresh squishy ones)

Instructions



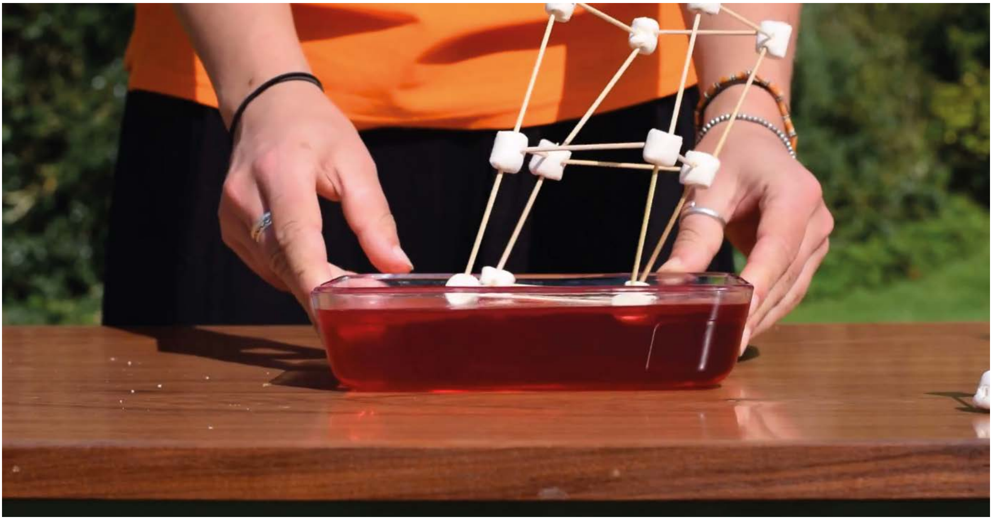
Make your jelly "ground" the night before by pouring it into a dish and leaving it to set overnight.

Next make some 3D structures using cocktail sticks and joining them together using marshmallows.

Place your structures on the jelly and slide your tray from side to side to simulate an "earthquake". How well do your structures stand up?
Are tall buildings, or short buildings better? What kind of shapes are strongest? Try making some cubes or pyramids – which work best?

What's happening?

You should find that short buildings are much more stable than tall buildings. This is because even though short and tall buildings shake at the same rate the shaking motion is magnified as buildings get taller. The strongest structures are often pyramids or tapered shapes which are wider at the bottom and get thinner towards the top. Triangles are very strong shapes and you can often make other shapes like cubes stronger by adding cross-bracing to form triangles.



FACT

Engineers use lots of other clever tricks to try and stop tall buildings like sky scrapers from shaking too much, including giant pendulums and detached bases.

KEY POINTS

- We can protect ourselves from earthquakes by designing earthquake resistant buildings
- Short buildings are less affected by earthquakes than tall buildings
- Tapered shapes and cross bracing improve resistance to shaking

INFO FOR INTERESTED ADULTS

How do you make tall buildings earthquake-proof?

SLINKY WAVES
Earthquake Body Waves

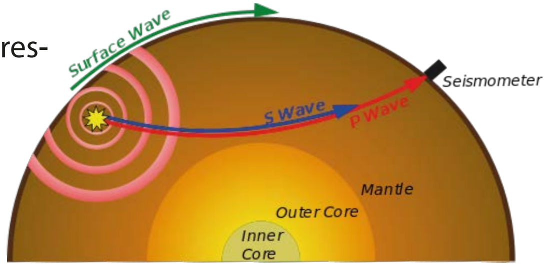
When an earthquake occurs energy spreads outwards, shaking the ground as it goes. Just like when you drop a pebble into a pond and see ripples spreading outwards on the surface, the energy from an earthquake also spreads outwards. There are several different types of earthquake waves...

Surface waves
Waves that travel along the top of the earth are called SURFACE waves. Surface waves have a complicated motion called a retrograde ellipse, which looks like drawing a backwards circle which moves forward.

Body Waves
Waves that travel inside the earth are called BODY waves. There are two different types of body waves:

P waves or Primary waves are compressional, vibrating in the direction of motion.

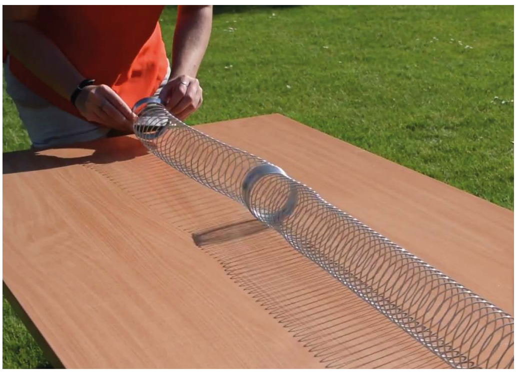
S waves or Secondary waves are transverse, vibrating perpendicular to the direction of motion.



What you'll need:

- A slinky
- A smooth surface

Instructions

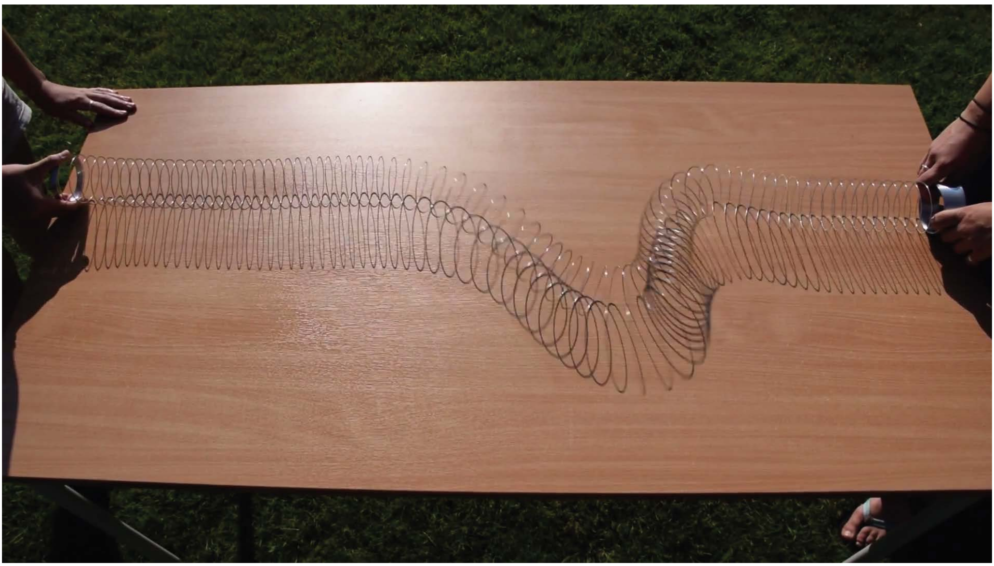


You can easily make your own P and S earthquake waves, to help you understand how they move, by simply using a slinky!

Find a smooth surface - either a table or the floor - and get a friend to hold the other end of your slinky. Stretch the slinky out between you until it is taut. To make an earthquake wave one of you moves their end of the slinky while the other person holds their end still.

To make a P wave: Give your end a sharp push forward before moving your hand back to where it started. You can see the P wave travelling towards your friend as compression and extension of the slinky.

To make an S wave: Give your hand a sharp flick out to one side before moving it back into the middle. You can see the S wave travelling towards your friend as side-to-side motion of the slinky.



EARTHQUAKE RACE
Earthquake Wave Speeds

For the 3 main types of waves - surface waves, P waves and S waves - which do you think is the fastest, and which is the slowest? You can have a race to find out! For this activity you need a big group of people (at least 15 or so).

Instructions

Split your group of people into 3 different teams. Each team will be a different wave (P, S or Surface). All 3 teams need to line up in 3 lines all facing forwards. The person at the back will start the "wave" motion which will get passed on until it reaches the person at the front, who can shout out the name of their wave. But each wave group has to pass on their wave as a different motion…

P waves are compressional, so this wave is passed on just by tapping the person in front.

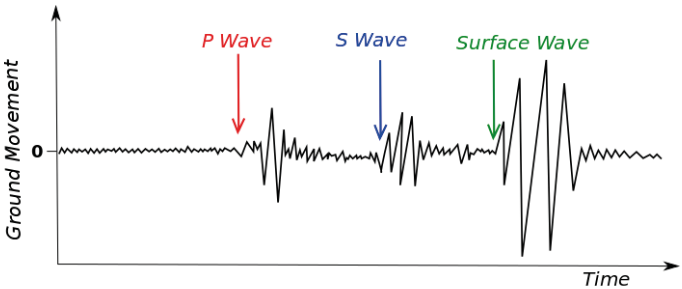
S waves are transverse, so this wave is passed on by reaching out as far as possible first to one side then the other side, before passing it on by tapping the shoulders of the person in front.

Surface waves have a backwards circular motion (retrograde ellipse), so for this wave you need to reach up in the air, reach far back behind you, bend down and touch the ground before reaching out to touch the person in front and passing on the wave (tracing out a backwards circle).

Begin your race with "On your marks, get set, go!" and see which wave reaches the front first. Try swapping teams to make sure one team is not just faster than everyone else. If you don't have enough people you can try timing each type of wave motion individually, along a single line.

What's happening?

You should notice that the P wave is always the fastest, then the S wave then the surface wave. We record the shaking of the ground on special instruments called SEISMOMETERS, we often see 3 big spikes in the signal. These relate to the P wave arriving (first), then the S wave arriving (second) and finally the surface wave arriving (third).



Seismometer

KEY POINTS

- Energy from an earthquake moves outwards in all directions in waves.
- Surface waves travel just along the earth's surface with a retrograde elliptical (backwards circle) motion.
- Body waves travel down inside the earth. The 2 types of body waves are **P waves** (compressional), and **S waves** (transverse).
- P waves travel fastest, then S waves and Surface waves are the slowest.

INFO FOR INTERESTED ADULTS

What other types of earthquake waves are there?
How do seismometers work?

Experiment Videos

Videos demonstrating each experiment can be found on our YouTube channel **Cambridge Volcano Seismlogy**, or simply scan the **QR code:**

Important Info for Adults

Experiments in this booklet are intended to demonstrate some of the scientific principles behind earthquakes and volcanoes. They use easy to get hold of items and can be tried at home or in the classroom. But beware, some are a little messy, and we advise adult participation with all experiments. Experiments are stand alone and can be done individually, however they also work well carried out in the order laid out here.

Further details about the underlying science and answers to "**Info for interested adults**" questions can be found on our website: **www.esc.cam.ac.uk/ExplosiveEarth** or simply scan the **QR code:**

Additional supporting **material for teachers** can also be found on our website.

Find Out More...

Try our google maps **lava flow simulation** game to discover how much of your neighbourhood would have been obliterated by the Holuhraun lava flow (Iceland, 2014): **www.esc.cam.ac.uk/ExplosiveEarth**

Explore the USGS **earthquakes games and activities**: **earthquake.usgs.gov/learn/kids**

Play the **Volcano Island** game and try to predict an eruption: **www.cfa.harvard.edu/earthscope/volcano_island**

Build your own volcano: **discoverykids.com/games/volcano-explorer**

Try the "**interactive earth**" game, to learn about how convection inside the earths solid mantle works: **ian-r-rose.github.io/interactive_earth**

Visit earthquakes and volcanoes worldwide: **earthquakes.volcanodiscovery.com**

Find out about the volcanoes of Iceland! Visit **futurevolc.vedur.is**

Try the **iSeismometer App** on your smart phone!

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