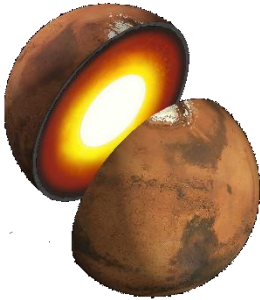
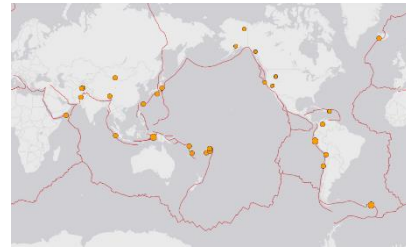


DEEP EARTH EXPLORERS - THINGS TO AT HOME WITH YOUR FAMILY OR FRIENDS

Learning about and being interested in the Earth doesn't have to stop here! Below is a list of websites and other activities to bring a little bit more geoscience into your life. All of these activities might be fun to share with your friends, siblings, or parents.

Learn more

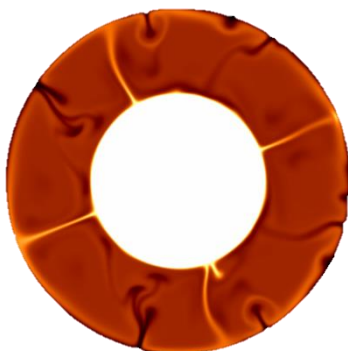
- Visit the Deep Earth Explorers Online Exhibition for more about seeing inside the Earth:
https://deepearth.esc.cam.ac.uk/?page_id=294
- Look at the Earth Science Cambridge blog to read about the interesting things the geoscientists in Cambridge have been up to, and the exciting places they've been: <https://blog.esc.cam.ac.uk/>



- Have a look at 'Earthquake watch' to keep track of recent earthquakes: <https://earthquake.usgs.gov/earthquakes/map/> (try fiddling with the settings to see recent earthquakes for the whole world, or earthquakes over a longer time periods e.g. 7 days, 30 days). You could also watch some computer simulations of recent Earthquakes: <https://global.shakemovie.princeton.edu/event.jsp>
- Follow the latest research on Mars. NASA recently landed a seismometer on Mars (the InSight mission) in order to study the interior of Mars: <https://mars.nasa.gov/insight/mission/science/overview/>

Things to make/do

- Make a pop-up Earth card: https://deepearth.esc.cam.ac.uk/?page_id=202 (this is a fun one to do with younger siblings), or have a go at one of the other fun activities on the Deep Earth Explorers website: https://deepearth.esc.cam.ac.uk/?page_id=14
- Watch The Core (2003) and play bad science bingo using the grid on the next page!



- Play with the convecting Earth model, to have a go at watching a model Earth convect and fire some seismic waves through it: https://ian-rose.github.io/interactive_earth/index.html
- Play one of the other volcano or earthquake geoscience games: <https://www.esc.cam.ac.uk/research/research-groups/cambridge-volcano-seismology/kids-activities-and-teaching-resources>

THE CORE (2003) – BAD SCIENCE BINGO

<p>A 'science' thing with an obviously made-up name (*cough cough* unobtainium *cough cough*)</p>	<p>The mantle is made of magma (we all know how wrong this is...)</p>	<p>Rock magically disappears when vaporised (where did all the rock vapour go???)</p>
<p>A cavern remains intact under the pressure of the mantle (plus, it's full of amethysts!)</p>	<p>The core <i>suddenly stopped</i> spinning (where did all the kinetic energy from the spinning go???)</p>	<p>Pigeons go mad because they've lost their compasses (last time you got lost, did you start running into buildings?)</p>
<p>Able to magically communicate through 4000km of rock with no delays</p>	<p>Unusual weather for no real reason (like every disaster movie ever)</p>	<p>A person sinking in magma (humans are less dense than magma, so would float... :-/ oops)</p>

FACT FILE: SEEING INSIDE THE EARTH

How do we LOOK inside the Earth?

Geoscientists do something similar to 'x-raying' the Earth to look inside of it. Instead of using x-rays, they use sound waves passing through the Earth. These vibrations, called **seismic waves**, can be caused by explosions, waves in the sea, or even cars, but usually geoscientists use waves generated by earthquakes.

Just like in an x-ray gives information about what kind of material it's passed through, e.g. bone or

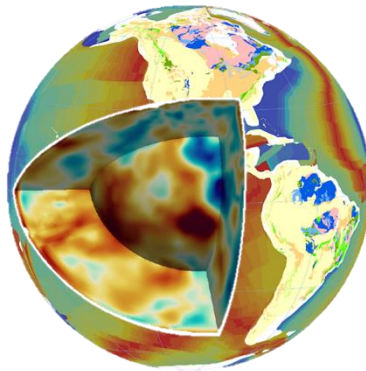
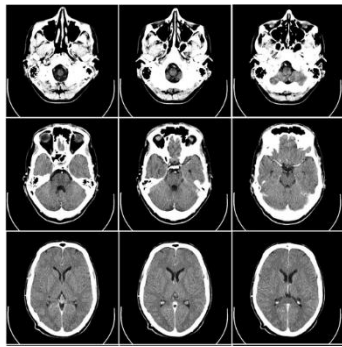


Figure 1 - (left) x-ray slices through a 3D CT-scan of a skull and (right) a 3D tomographic image of the Earth made in a similar way

muscle, **seismic waves** can give information about the Earth material they have passed through. In a medical CT (computer **tomography**) scan, x-rays are taken from all directions around a part of the body, and then combined to make a 3D image. Similarly, if we record lots of seismic waves going in different directions, we can computationally combine them to make 3D seismic **tomographic images** of the Earth.

What does the image show us?

In an x-ray, the colours show us how strongly different areas absorb x-rays.

Seismic tomography is a little different.

What the image shows is the difference between the actual speed of the **seismic waves** in an area, and the speed of seismic waves we would expect. We can work this out by looking to see if rays passing through that area are moving faster or slower than we would expect.

If they arrive late, then we know that seismic waves move more slowly in the area they've passed through (and the opposite for waves arriving early).

What affects how fast seismic waves travel?

Lots of things! For example: the type of rock, or the size of the crystals in the rock. But the most important factor is **temperature**. When materials are hot, their particles are further apart and moving more. This means that it takes longer to pass a vibration between them, so sound moves slower through warmer material. Imagine a line of people. Will it take longer to pass a message down the line if everyone is standing still, or if everyone is running from side-to-side? It'll clearly take longer if everyone is moving all the time.

We can, therefore, say that **faster seismic wave speeds usually mean colder material, and slower seismic wave speeds mean hotter material**. (In the image in figure 1, red is hot, and blue is cold.)

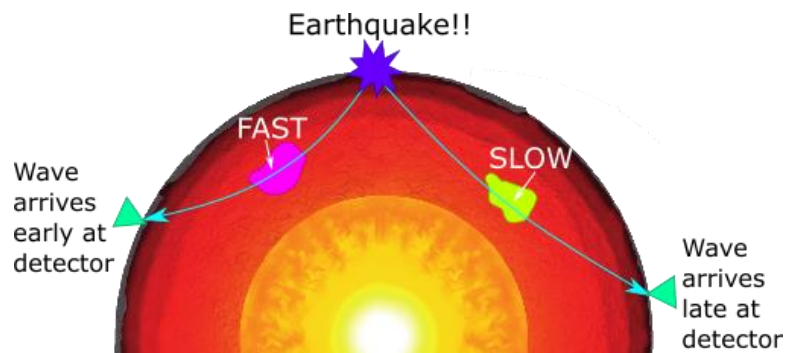


Figure 2 - Example of two waves moving through the Earth, showing how we can tell seismic wave speed from whether waves arrive early or late

GLOSSARY - Useful terminology from the workshop

Solid	A state of matter (like liquid or gas), where the particles in the material have fixed, and typically ordered, positions which they vibrate about.
Fluid	A material, in any state, which can flow.
Geosciences	A subject concerned with the workings of the Earth and other planets. It includes study of the climate, oceans, atmosphere, life and evolution, volcanoes, rocks, earthquakes, the deep interior of the Earth, and these same phenomena on other planets.
Convection	The transfer of heat by the movement of hot material upwards and cold material downwards.
Mantle	The second layer of the Earth, below the crust and above the outer core, which makes up 84% of the Earth's volume and is made of solid rock.
Seismic waves	Vibrations (sound) which pass through the solid Earth, typically produced by earthquakes.
Seismometer	A sensitive instrument which measures the vibrations of the Earth's surface caused by seismic waves.
Tomography	The production of 3D images and 2D slices of the inside of a 3D solid by measuring rays passing through the solid; for example, medical tomography of the body using x-rays or seismic tomography of the Earth using seismic waves.
Mantle plume	An area of hotter than usual mantle which rises upwards, and causes melting of the mantle beneath the base of the crust, resulting in volcanoes. Famous examples are beneath Hawaii and Iceland. This movement upwards of hot mantle is part of the convection of the mantle.
Subduction	The downwards movement of a cold plate of the Earth's crust and upper mantle into the warmer mantle, below another plate. The movement of the cold mantle and crust downwards is part of the convection of the mantle.
Peridotite	The green rock which makes up the Earth's mantle. It is made of crystals of the minerals Olivine and Pyroxene.
Kimberlite pipe	A volcano with a magma source from melting deep in the mantle. They frequently bring up pieces of peridotite in their magma, and are famous for being where diamonds are found in the Earth's crust.
Creep	The gradual flow of solids, caused by the addition of many tiny movements of the particles which make up the solid, for example crystals sliding past each other, or dissolving and re-crystallising.
Linear	A scale which goes up in even steps.
Logarithmic	A scale where each time you go up one along the scale the number gets ten times bigger.