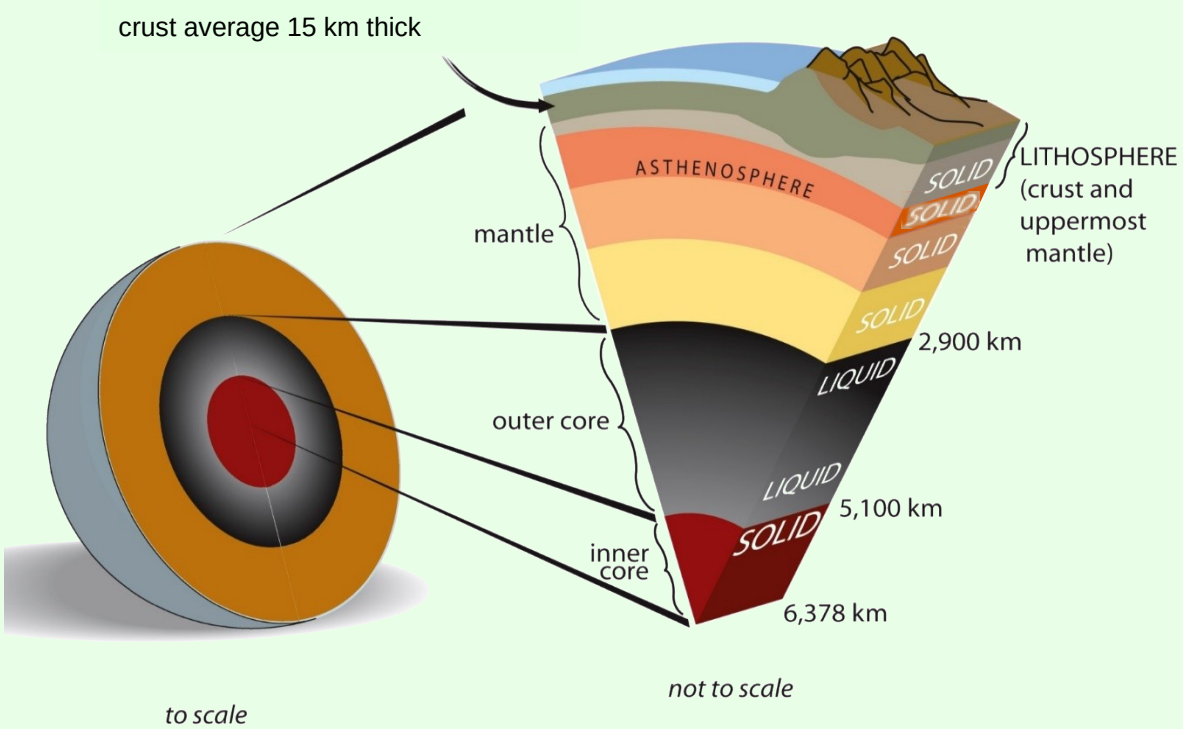
Investigating Earth's structure – online

Earth Science for science and geography – video workshop



Developed from the Earth Science Education Unit 'Investigating Earth's structure' workshop, with permission

Earthlearningidea online video workshops

Purpose – ESEU background

- Most Earthlearningidea online video workshops are based, with permission, on workshops originally developed by the Earth Science Education Unit (ESEU)
- These were designed as interactive workshops for teachers and trainees, involving interaction, discussion and presentations by participants to others
- Global research into professional development workshops shows that these aspects are critical to success
- ESEU research shows that this workshop approach is highly successful in changing teaching in schools; evaluation feedback has also been very strong

Earthlearningidea online video workshops

Purpose – Earthlearningidea development

- The Earthlearningidea Team has developed the ESEU workshops into online video workshops for those unable to take part in face to face interactive workshops
- Each workshop is led by a PowerPoint presentation and has an accompanying booklet that contains all the activity background details, resource lists, risk assessments, etc.
- The individual workshop activities have been published for open access online at the website: https://www.earthlearningidea.com/
- Each workshop activity has a question script and a video keyed into CASE principles, that can be accessed through the PowerPoint hyperlinks
- The aim is to facilitate online Earth science learning

Earthlearningidea online video workshops

Teaching Earth science using the Cognitive Acceleration through Science (CASE) approach

- The activities in this workshop are keyed into the CASE approach – to develop thinking skills while teaching key Earth science material
- If you are unfamiliar with the case approach, you can access a video introduction at: https://www.earthlearningidea.com/Video/CASE.html
- An exemplar Earth science teaching activity with a question script using the CASE approach is at: https://www.earthlearningidea.com/Video/Atmosphere_ocean.html

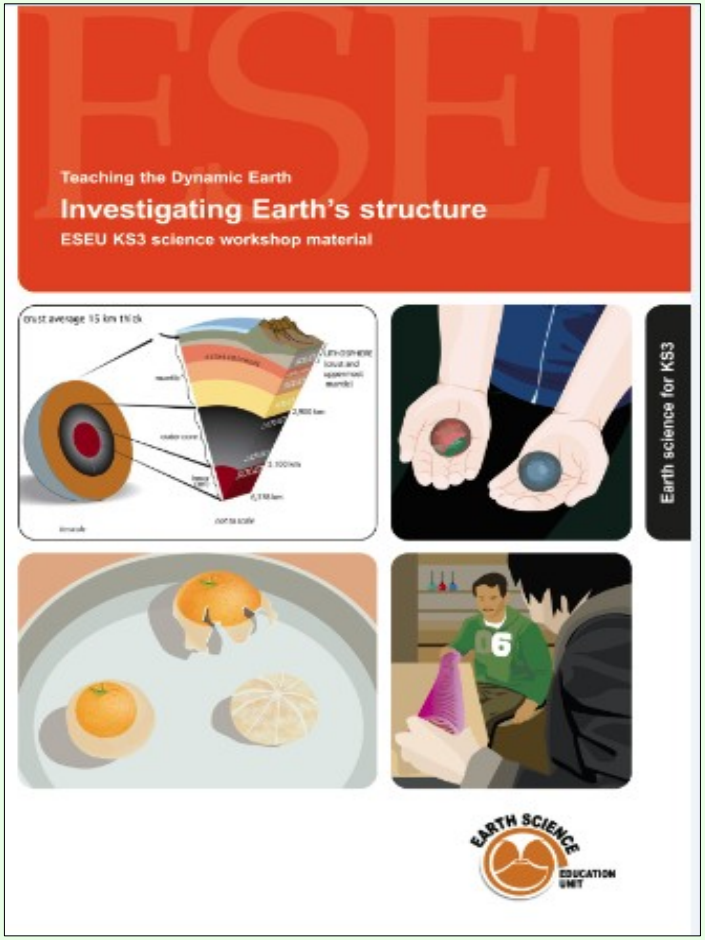
Earthlearningidea online video workshops

Running Earthlearningidea online video workshops

- Each workshop is led by a PowerPoint presentation
- Launch the PowerPoint
- Some slides contain hyperlinks to MP4 video files
- Run the hyperlinked files and then return to the PowerPoint, flick through any slides you have already seen, and continue
- The workshop is presented in this way so that the workshop itself, or individual videos, can be used in classroom teaching

Investigating Earth's structure

Workshop video run times		m	s	m	s
Investigating Earth's structure				**44**	**54**
From clay balls to the structure of the Earth				10	01
From an orange to the whole Earth				2	30
Earthquakes – the slinky simulation				3	37
Wave motion – the pupil molecules				3	07
Seismic evidence and potty putty mantle	Seismic evidence	3	18	8	43
	Solids that flow	4	19		
	Skateboard summary	1	06		
Journey to the centre of the Earth				3	38
The wax magnetic field and magnetic Earth	Frozen magnetism	2	08	13	18
	Magnetic Earth	6	30		
			4		



Investigating Earth's structure

Earth science for geography and science

The workshop is based on this pdf booklet originally prepared by the Earth Science Education Unit and now available on the Earthlearningidea website. It contains a workshop summary, the outcomes, teacher guidance, risk assessments and resources lists – as in the following slides

Investigating Earth’s structure

Summary

Try a series of ‘hands-on’ demonstrations and activities to highlight key aspects of the structure of the Earth and the evidence we have for this structure. The practical activities address common misconceptions about the state (solid/liquid) of the Earth’s layers and about the thickness of the crust and the Earth’s dimensions.

Investigating Earth's structure

Workshop outcomes

The workshop and its activities provide the following outcomes:

- insights into the structure of the Earth and the dimensions of the Earth's layers;
- discussions and demonstrations about the state (solid/liquid) of the layers;
- the evidence we have for the dimensions and state of the layers;
- means of addressing common misconceptions about the Earth's structure;
- links to the science and geography of Earth's structure;
- guidance on how the elements of Earth science in the curriculum can be taught most effectively.

Investigating Earth's structure

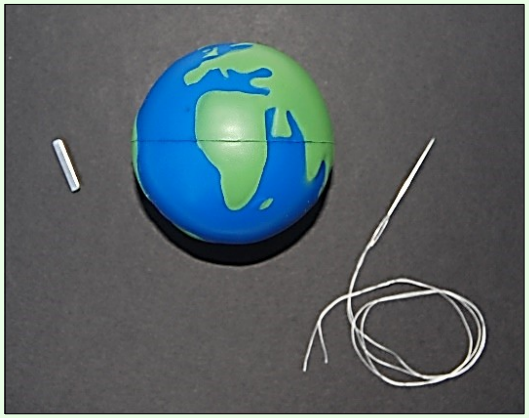
Explore the processes using this wide range of activities:
Practical activities needing apparatus/materials are shown with a *

- From clay balls to the structure of the Earth*
- From an orange to the whole Earth*
- Earthquakes – the slinky simulation*
- Wave motion – pupil molecules
- The seismic evidence
- Solids that flow*
- Skateboard summary
- Journey to the centre of the Earth – on a toilet roll*
- Frozen magnetism*
- Magnetic Earth*
- Magnetic Earth using a sponge ball globe*

Investigating Earth's structure

Carry out risk assessments before the following activities:

Wave motion – pupil molecules
Magnetic Earth
Magnetic Earth using a sponge ball globe



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Earth's structure

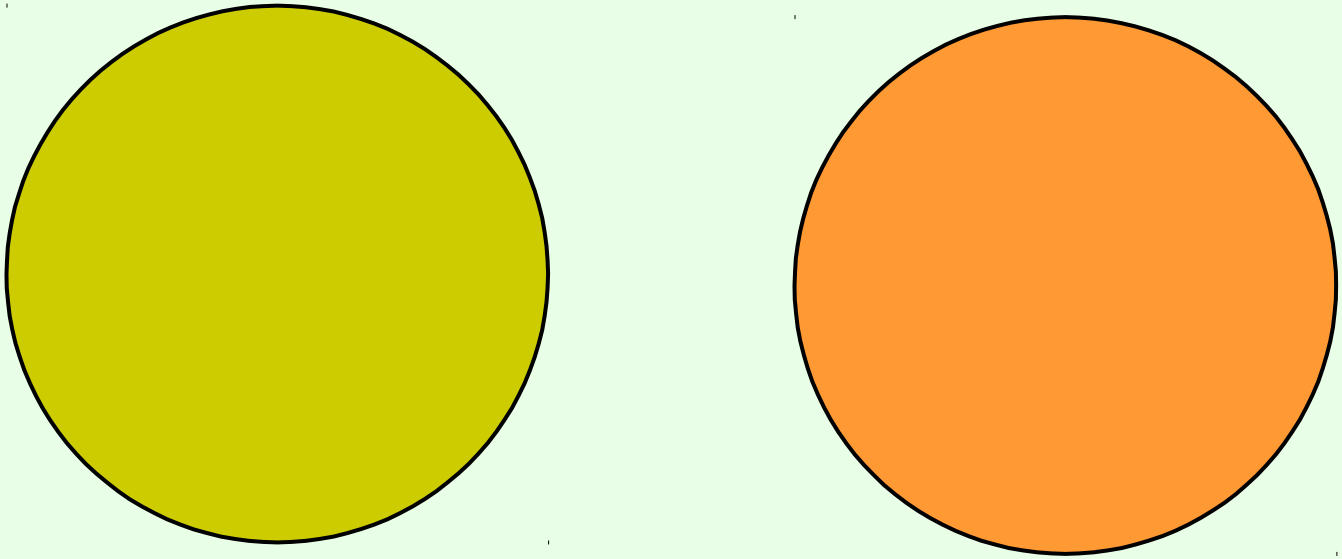
- **From clay balls to the structure of the Earth**

Go to: https://www.earthlearningidea.com/Video/V20_Clay_balls.html hyperlink

Investigating Earth's structure

From clay balls to Earth's structure

- Two spheres, different colours - other differences?



- One ball seems heavier than the other
- How could you find out if you are right?

Investigating Earth's structure

From clay balls to Earth's structure

To find out if one ball is heavier than the other, you could:

- Weigh both balls – you would find that one has a greater mass than the other
- Spin or roll the balls – one should spin or roll better than the other because it is heavier and has more inertia

The spin/roll test doesn't work because the Plasticine™ will not allow free spinning/rolling

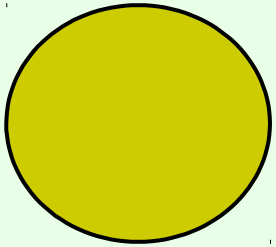
One ball is heavier than the other. Why? There are five different ideas (hypotheses) that could account for this – discuss the possibilities

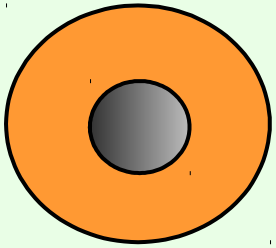
Investigating Earth's structure

From clay balls to Earth's structure

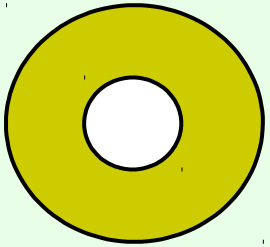
One feels heavier, and it is - reasons could be:

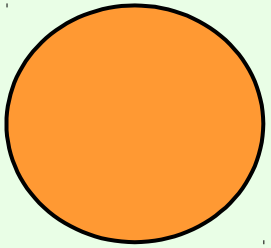
something heavy in the centre of the heavy one



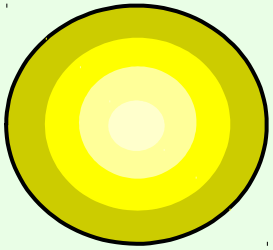


something light in the centre of the light one

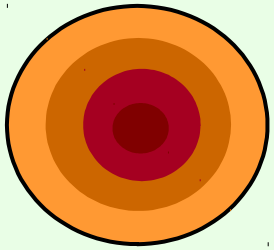




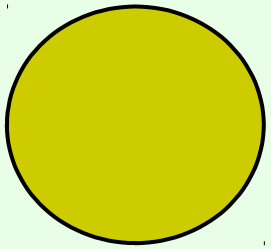
one gets steadily lighter towards the centre

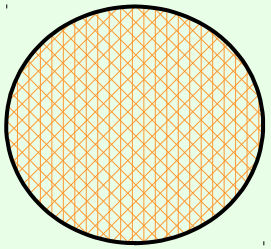


one gets steadily heavier towards the centre



one is made of heavier 'stuff' than the other





How could you find out which is right - without destroying the ball?

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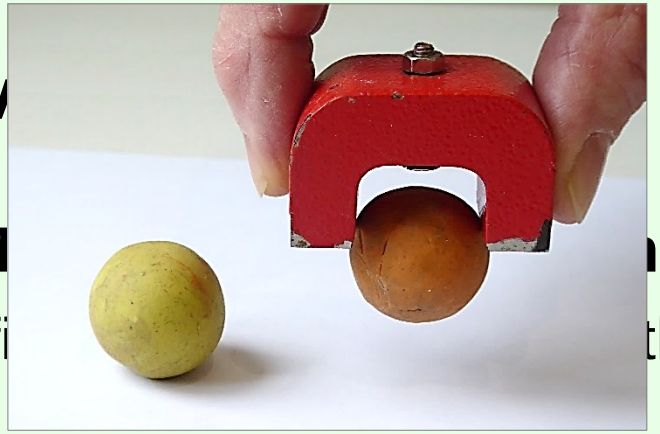


How could you fi thout

i	Stick a pin in	The pin would stop at the ball bearing
i	Take a small piece of the surface and test its density	The densities would be the same
i	Test with a magnet	The magnet would attract the ball bearing
i	Test its inertia	The inertia test does not work with clay
i	Test it with ultrasound	Ultrasound would find the ball bearing
i	X-ray it	X-rays would find the ball bearing
i	Test it with ionising radiation (α, β, γ)	Ionising radiation would find the bearing

Which of these could you use on the Earth in an attempt to find out what is in the middle?

Investigating Earth's structure

From clay balls to Earth's structure

Which of these could you use on the Earth to find in an attempt to find out what is in the middle?

- Stick a pin in - no, can't drill that deep
- Measure density* - yes, crustal density less than whole Earth density
- Magnetism * - yes, measure and interpret effects
- Inertia * - yes, measure and interpret effects
- Ultrasound - no, can't penetrate that far
  - Sound (sonar) - no, bounces off seafloor
  - Infra-sound * - yes, low frequency sound = seismic waves – gives the best evidence for the core
- X-ray - no, can't penetrate that far
- Ionising radiation - no, can't penetrate that far

* Gives evidence for the Earth's core

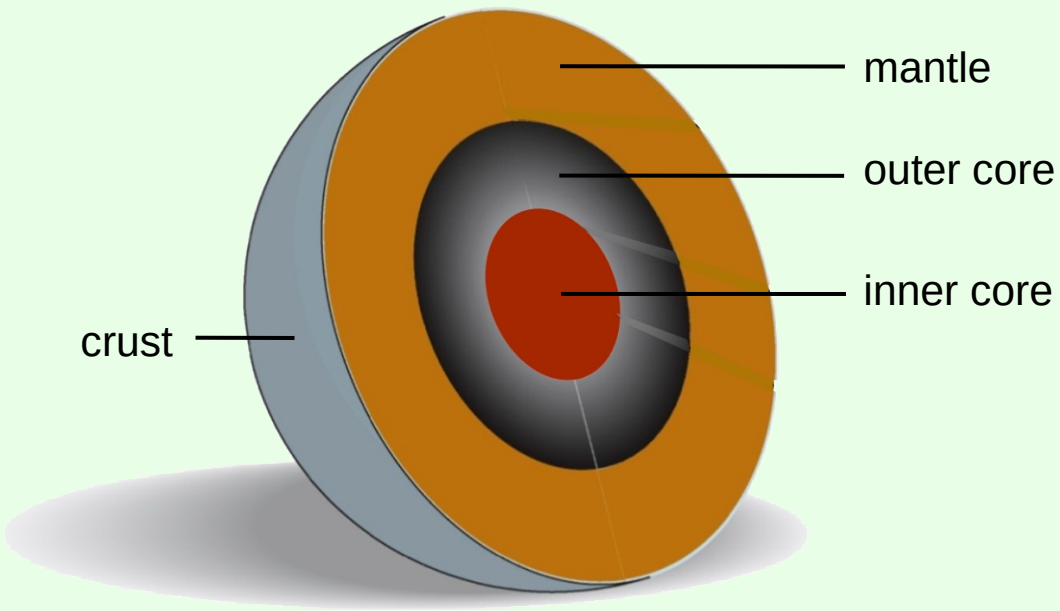
Note: The activity is fully explained in, King, C. (2002) The secrets of Plasticine balls and the structure of the Earth: investigation through discussion, published in *Physics Education,* 37 (6), 485 – 491.

Investigating Earth's structure

From clay balls to Earth's structure

Through this activity – have we been learning about science/geography or 'doing science/geography'?

When learning about the Earth's core, you might have been asked to draw and label a diagram like this:



…. or you could have done the activity we have just done

Investigating Earth's structure

From clay balls to Earth's structure

Through this activity – have we been learning about science/geography or 'doing science/geography'?

When scientists or geographers 'do' science/geography they:

- ask questions
- come up with ideas to answer these questions (develop hypotheses)
- think of ways of testing these ideas (observations or experiments)
- think about what these are likely to tell us

… just as we have been doing here

So – is this way of exploring Earth's core 'doing science/ geography' – or just learning about it?

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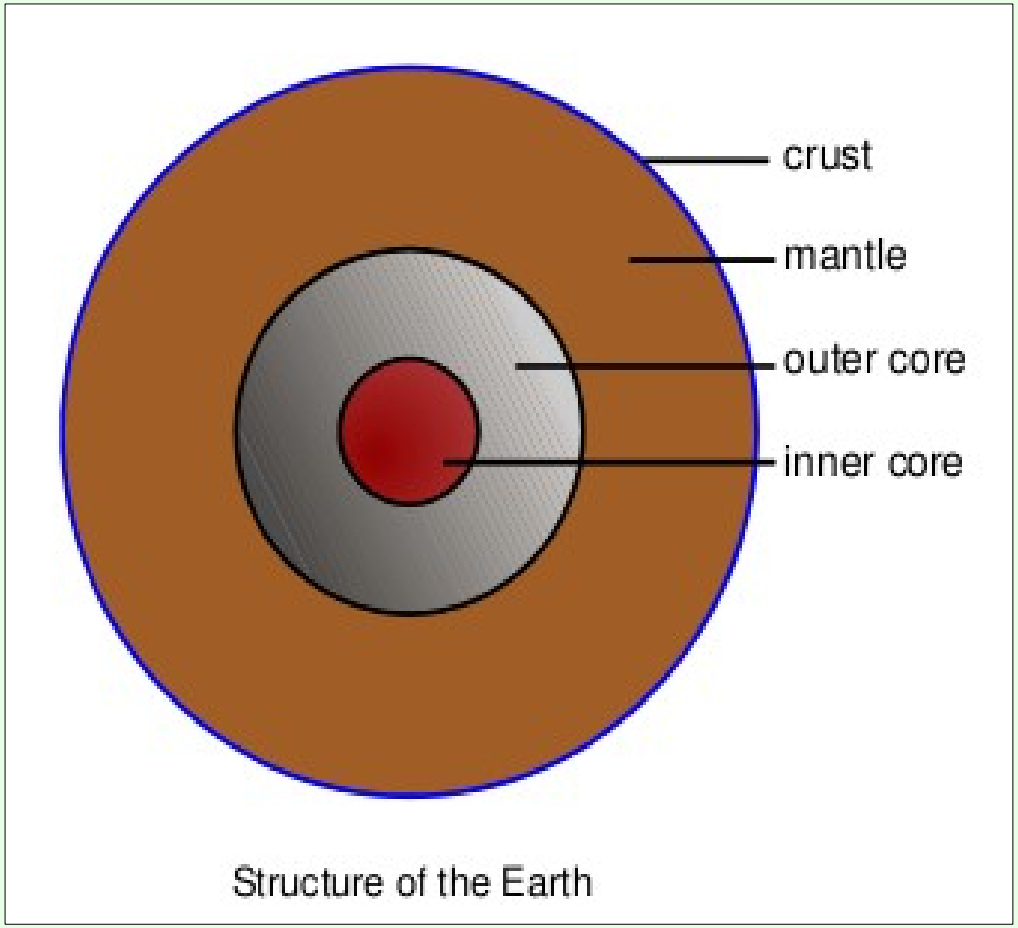
Earth's structure

- **From an orange to the whole Earth**

Go to: https://www.earthlearningidea.com/Video/V23_Orange_to_Earth.html hyperlink

Investigating Earth's structure

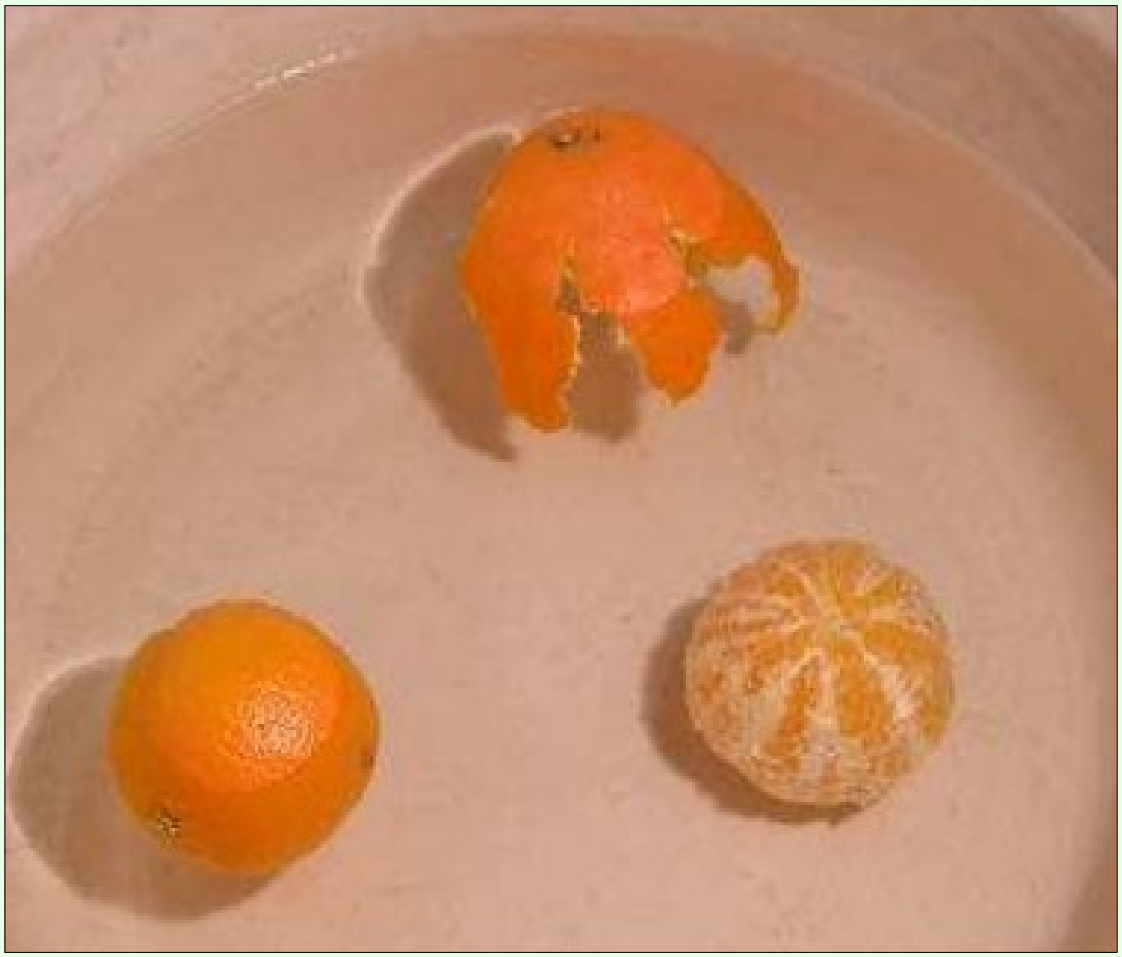
From an orange to the whole Earth



Structure of the Earth

Investigating Earth's structure

From an orange to the whole Earth



Investigating Earth's structure

From an orange to the whole Earth

Density of the Earth and its layers – the figures:

Earth Layer	**Density, gcm^{-3}**
Crust	2.7 (oceanic) – 2.9 (continental)
Mantle	3.3 – 5.7
Outer core	9.9 – 12.2
Inner core	12.6 – 13.00
Whole Earth	5.5

Teaching Earthlearningideas

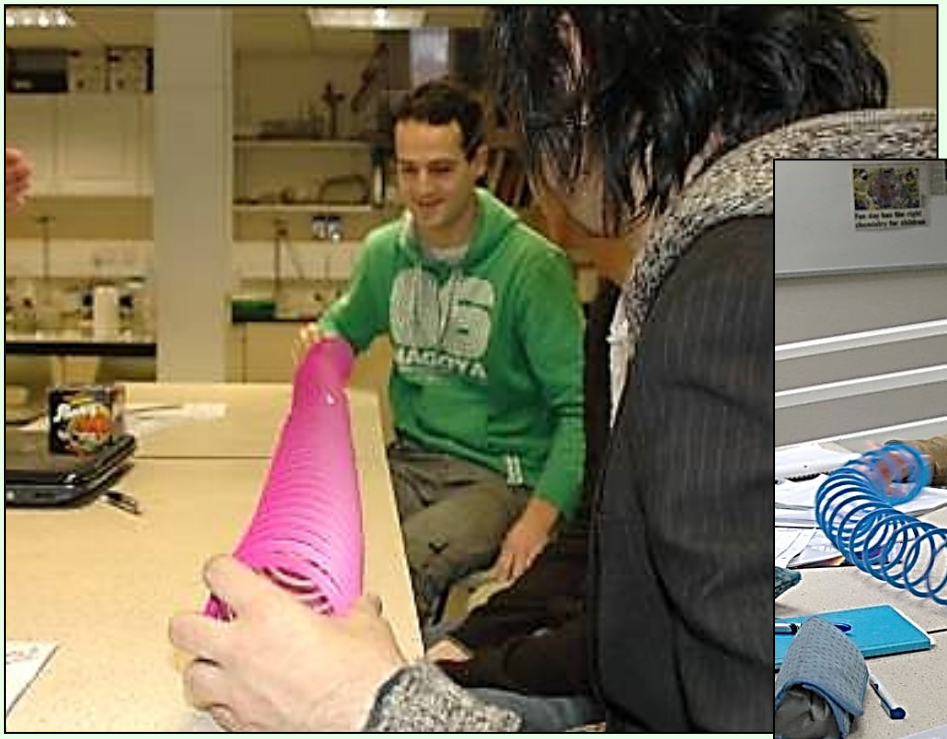
Earth's structure

- **Earthquakes – the slinky simulation**

Go to: https://www.earthlearningidea.com/Video/V22_Slinky_simulation.html
hyperlink

Investigating Earth's structure

Earthquakes - the slinky simulation
How earthquakes produce **P**- and **S**-waves



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Earthquakes - the slinky simulation
How earthquakes produce **P**- and **S**-waves

Investigating Earth's structure

Seismic wave summary

Wave type	**Primary wave**	**Secondary wave**
Name meaning	fastest wave, so arrives first, called primary	slower wave, arrives second, called secondary
Other names	longitudinal – travels by vibration along the material	transverse – travels by lateral movement
	push/pull wave; comPressional wave	shake wave; shear wave; sideways wave; slow wave
Transmission	through solids and fluids (liquids and gases)	through solids only

Earthquake damage is caused mainly by seismic **surface waves**, and not by primary or secondary waves

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- **Wave motion – pupil molecules**

Go to: https://www.earthlearningidea.com/Video/V22_Pupil_molecules.html hyperlink

Investigating Earth's structure

Wave motion – pupil molecules
How **P**- and **S**-waves are transmitted

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Earth's structure

- **The seismic evidence**

Go to: https://www.earthlearningidea.com/Video/V26_Seismic_evidence.html
hyperlink

Investigating Earth's structure

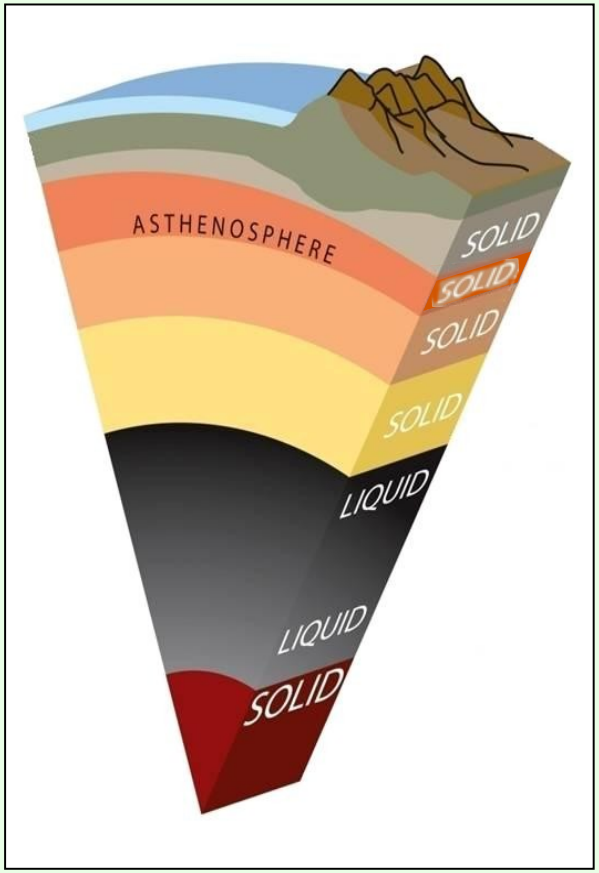
Seismic evidence

Seismic waves are shock waves that pass through and around the Earth

Seismic waves are generated naturally by earthquakes

There are three main types:

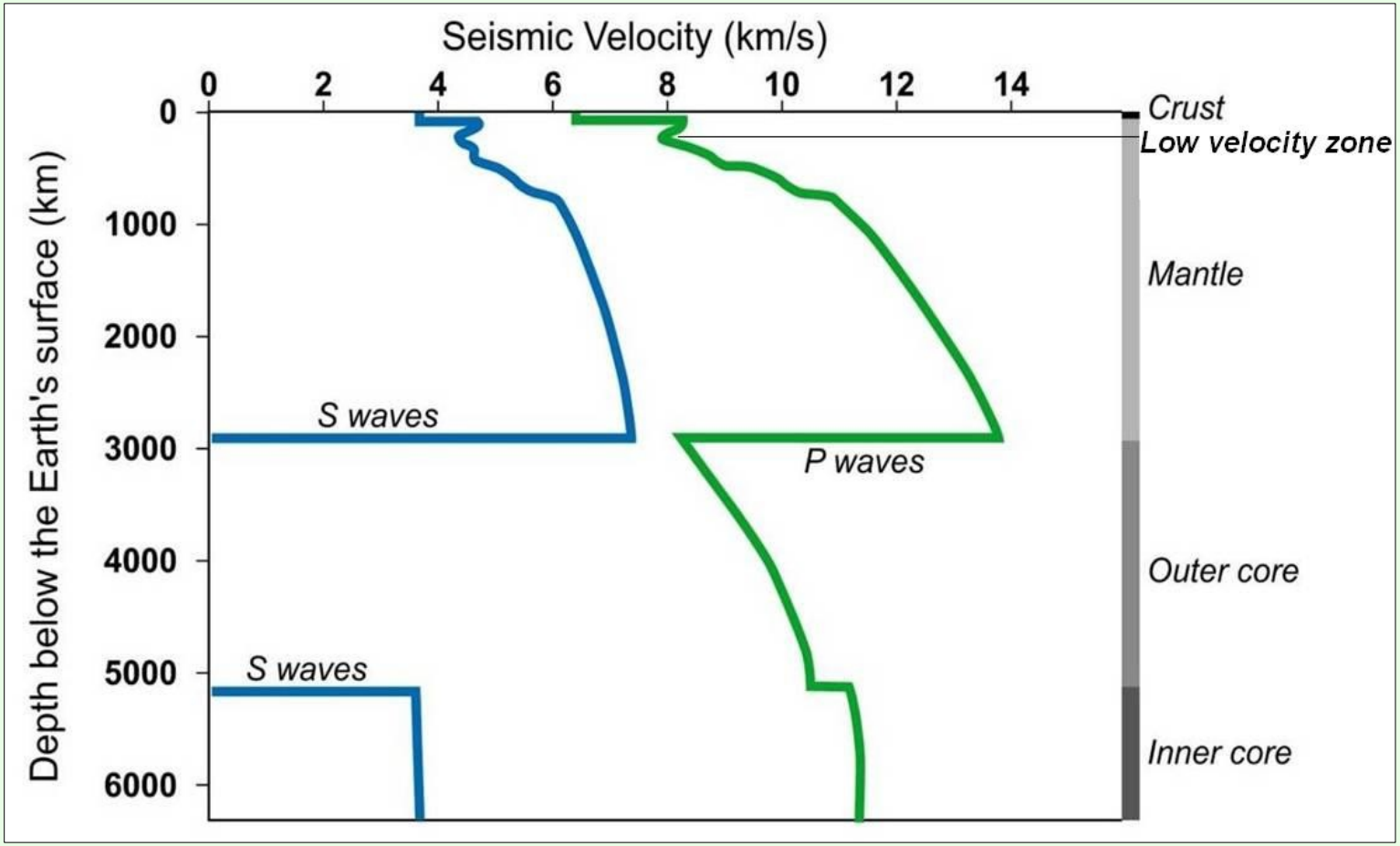
- P-waves – travel through solids and fluids (liquids and gases); pass through the Earth
- S-waves – travel only through solids (not fluids); pass through the Earth
- Surface waves – formed when P- and S-waves reach the Earth's surface; these cause most damage



The Structure of the Earth – from the seismic evidence – reproduced with kind permission of USGS, redrawn by ESEU

Investigating Earth's structure

Velocities of P- and S-waves as they travel into the Earth



Graph of 'Velocities of P and S waves as they travel into the Earth © ESTA, redrawn by ESEU

- P-waves – travel through solids and fluids (liquids and gases);
- S-waves – travel only through solids (not fluids);

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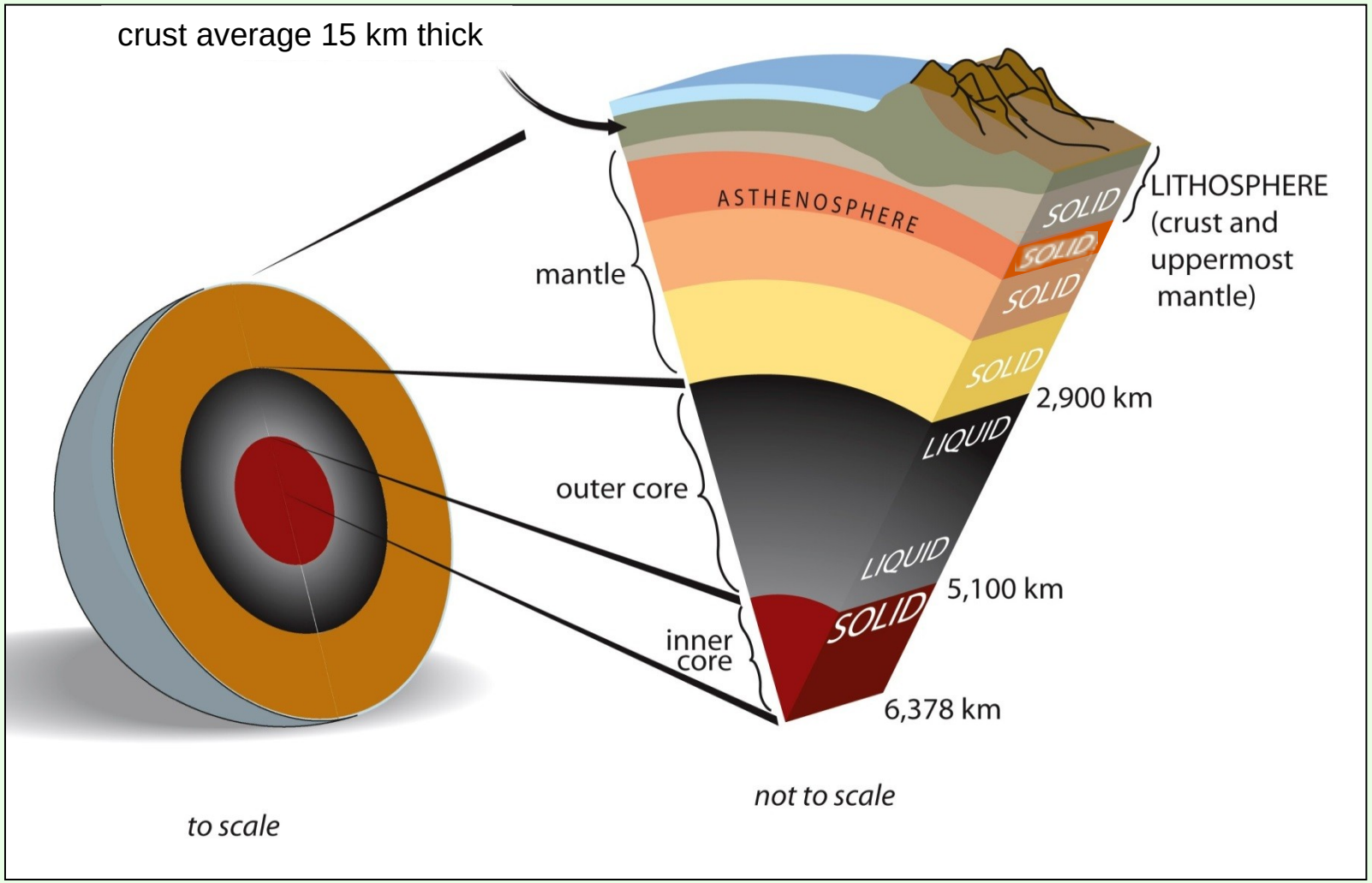
The structure of the Earth – from the seismic evidence



The Internal structure of the Earth - reproduced with kind permission of USGS, redrawn by ESEU

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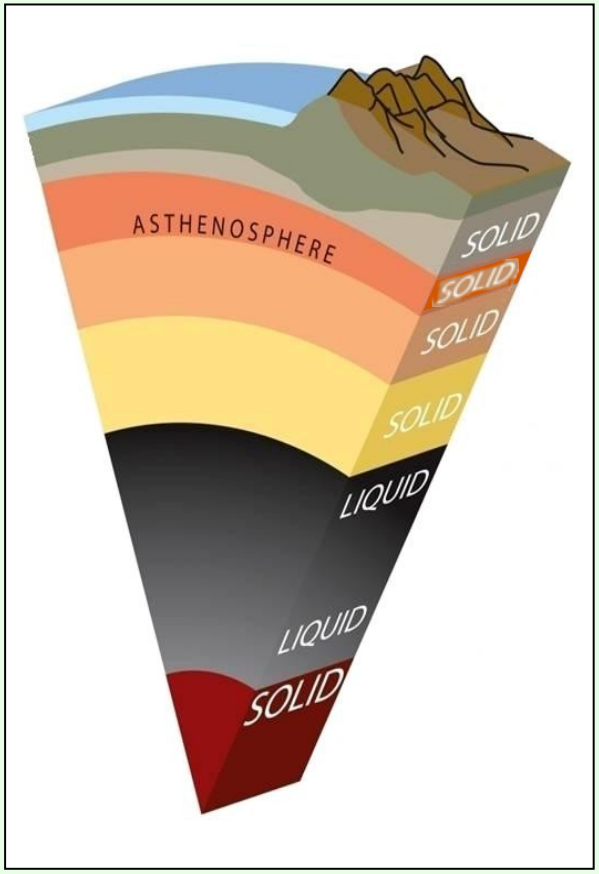
Seismic evidence – summary

The outer core is liquid (no S-waves transmitted)

The inner core is solid (transmits S-waves)

The rest of the Earth is also solid – the crust, the lithosphere, the asthenosphere and the rest of the mantle (transmits S-waves)

Seismic waves slow down in the asthenosphere (low velocity zone) because the solid asthenosphere is near its melting point and so is plastic and can flow



The Structure of the Earth – from the seismic evidence – reproduced with kind permission of USGS, redrawn by ESEU

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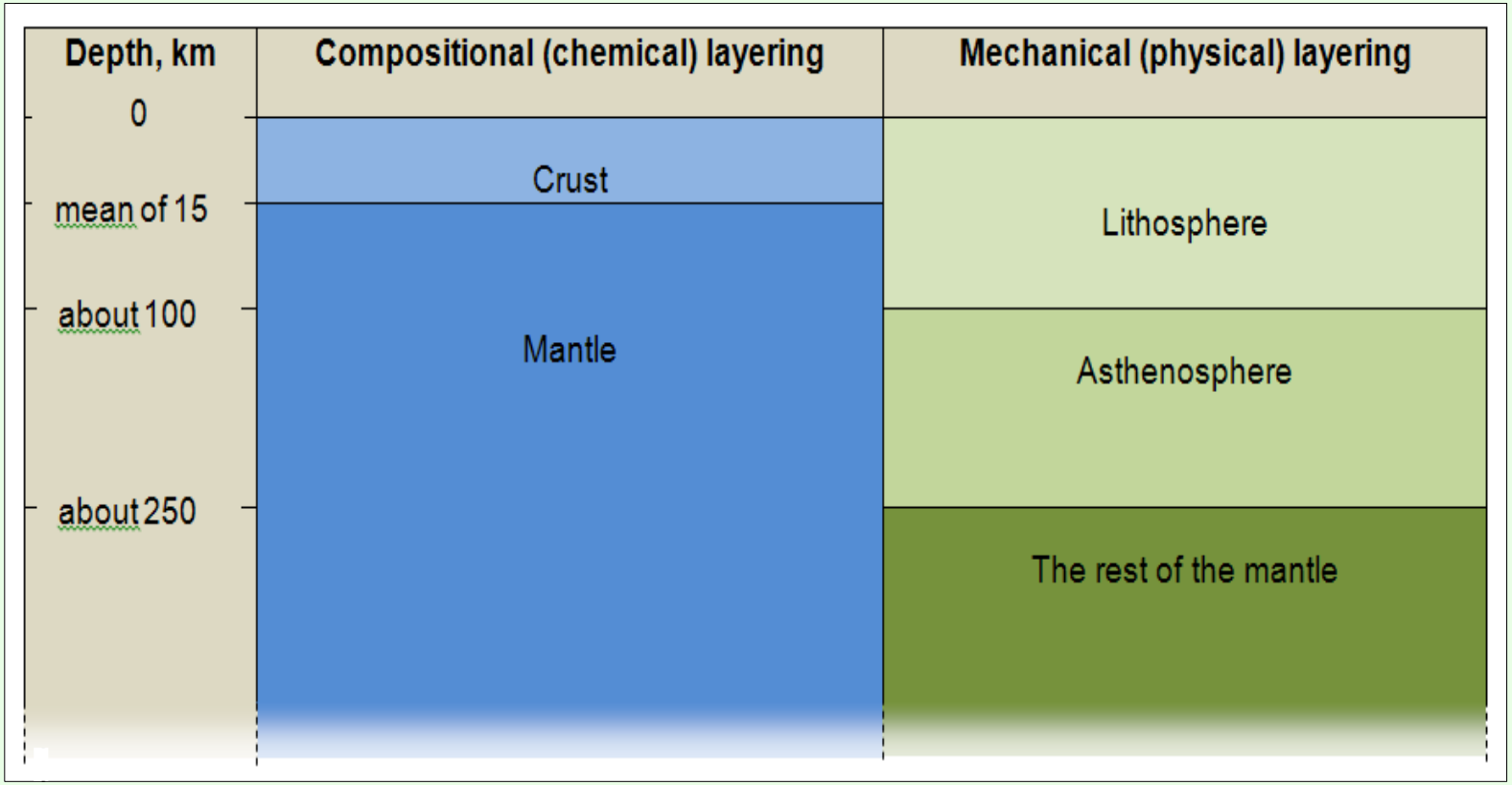
The lithosphere, asthenosphere and below:



The lithosphere, asthenosphere and below © ESEU

Note 1. The crust has a mean thickness of 35 km beneath continents and 6 km beneath oceans giving an overall mean of about 15 km.

Note 2. The crust is too thin to form plates – plates are made of rigid lithosphere – around 100 km in thickness

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Earth's structure

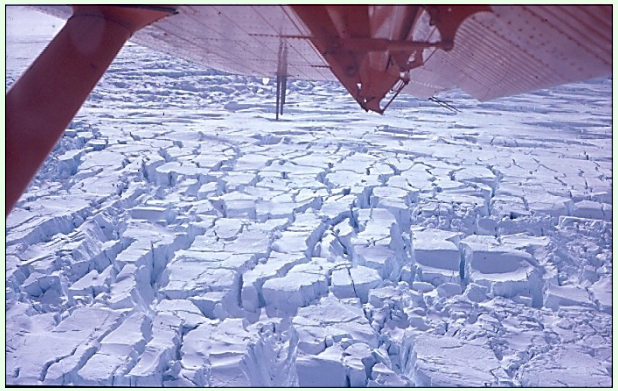
- **Solids that flow**

Go to: https://www.earthlearningidea.com/Video/V26_Potty_putty.html hyperlink

Investigating Earth's structure

Can solids flow?

- Can you think of a common solid that flows?
- Answer = ice
- Ice is solid – and can break (fracture)
- Ice is solid – but when near its melting point in a glacier on a mountainside – it flows
- It flows even in polar glaciers – which are frozen to the ground



Fractured ice – seen from a plane in Antarctica

A glacier flowing downhill in Norway

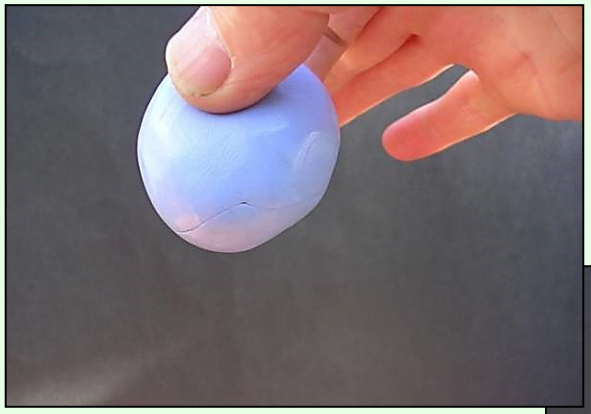
Investigating Earth's structure

Properties of the mantle – potty putty™
Showing how the solid mantle can flow

Student pulling Potty Putty™ © ESEU

Investigating Earth's structure

Modelling the mantle



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Modelling the mantle - summary

- How are 'potty putty' and the mantle similar?

Potty putty	The mantle
Breaks – brittle behaviour	Mantle in the lithosphere breaks – causing earthquakes
Bounces – elastic behaviour	Transmits earthquake (seismic) P- and S-waves
Bends, flows – plastic behaviour	Can flow (over geological time)

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Earth's structure

- **Skateboard summary**

Go to: https://www.earthlearningidea.com/Video/V26_Skateboard.html hyperlink

Investigating Earth's structure

Modelling the lithosphere and asthenosphere (?)

Skateboard © Peter Kennett, ESEU

Investigating Earth's structure

Modelling the lithosphere and asthenosphere (?)

The crust – trainers	The extreme upper mantle – skateboard	The asthenosphere - wheels

Skateboard © Peter Kennett, ESEU

The asthenosphere (wheels) flows, carrying the plate of lithosphere = trainers (crust) + extreme upper mantle (skateboard) along

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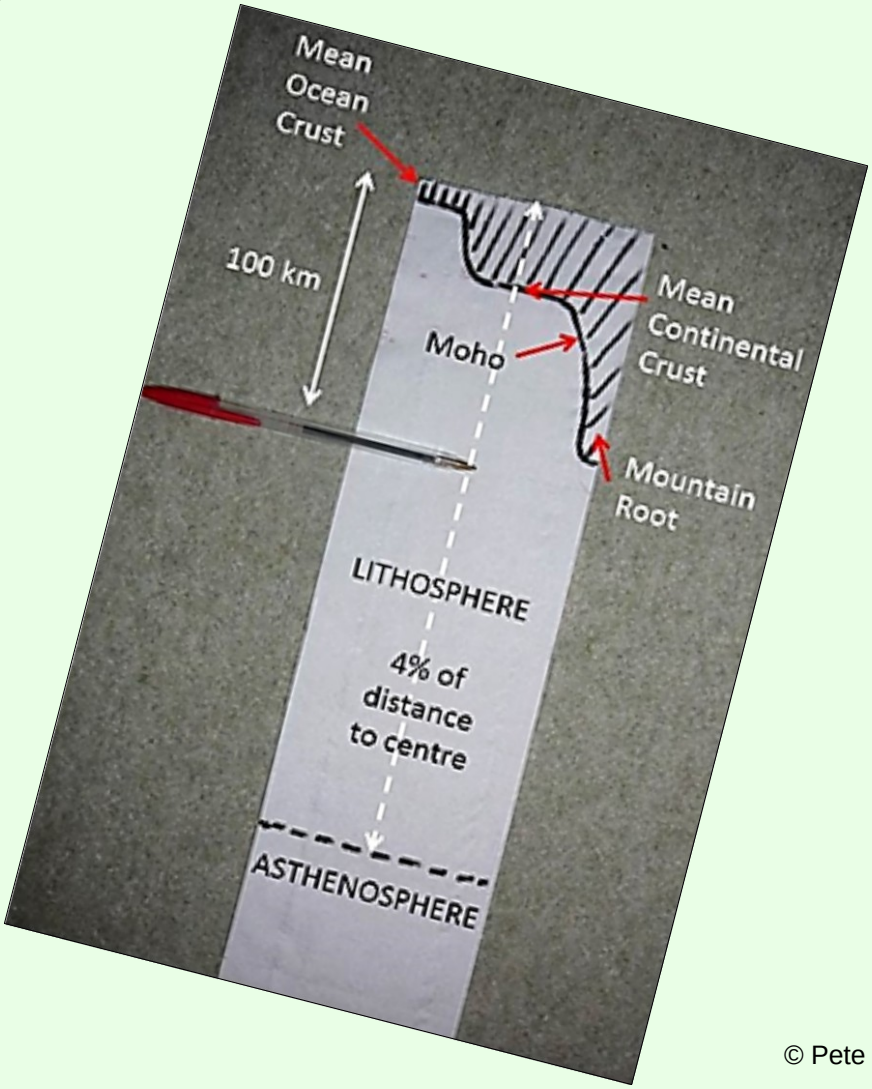
Earth's structure

- **Journey to the centre of the Earth – on a toilet roll**

Go to: https://www.earthlearningidea.com/Video/V27_Journey_toilet_roll.html
hyperlink

Investigating Earth's structure

Journey to the centre of the Earth – on a toilet roll



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Earth's structure

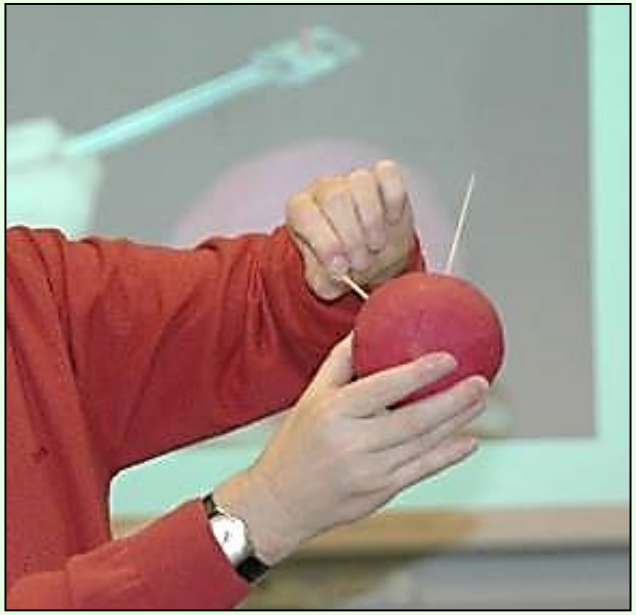
- **Frozen magnetism**

Go to: https://www.earthlearningidea.com/Video/V24_Magnetism1.html hyperlink

Investigating Earth's structure

The magnetic evidence
From magnetic globe to magnetic rock evidence

Petri-dish magnetic field preserved in iron filings in wax © Michèle Bourne, ESEU



Model magnetic Earth (ESEU)

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Earth's structure

- **Magnetic Earth**

Go to: https://www.earthlearningidea.com/Video/V24_Magnetism2.html hyperlink

Investigating Earth's structure

Model magnetic Earth

Model magnetic Earth (ESEU)

Investigating Earth's structure

Model magnetic Earth

- How many degrees does the magnet on the Magnaprobe™ rotate through as it is moved from one pole to the other?
- 360^{o} or back to the start = 0^{o}

Investigating Earth's structure

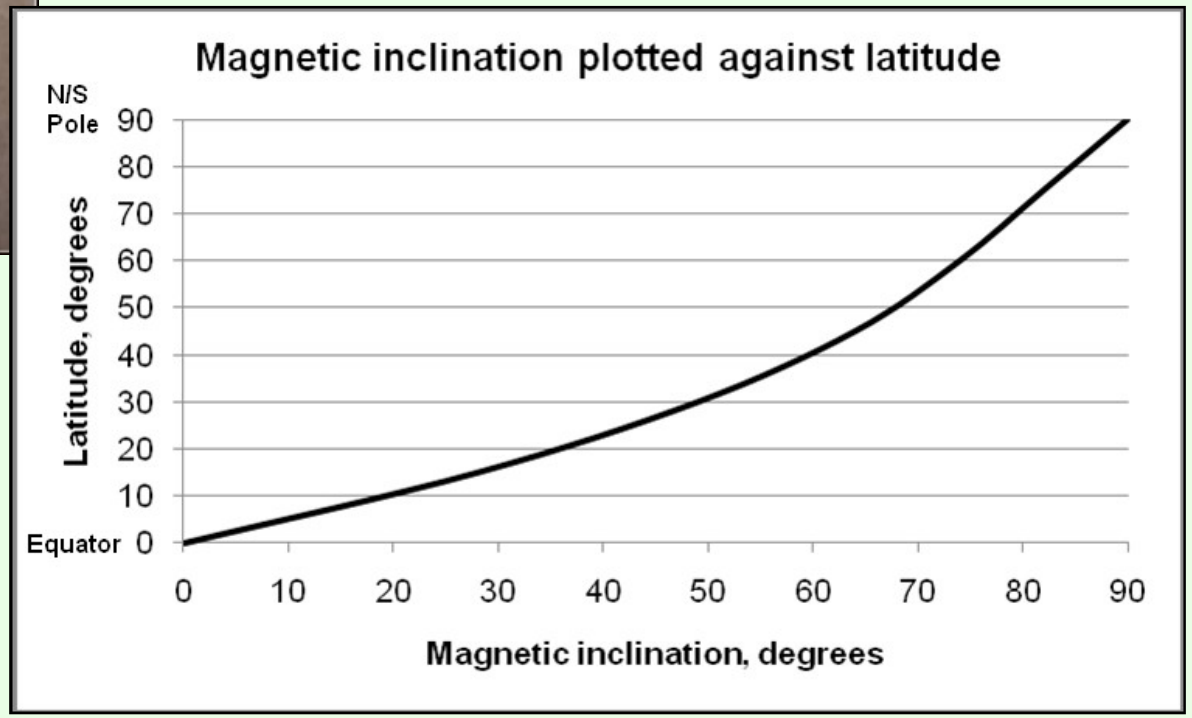
Model magnetic Earth

- If a volcano erupted at the North Pole, what angle (dip) would the magnetism recorded there have (the remanent magnetisation)?
- Vertical (90^o)
- If a volcano erupted at the South Pole, what dip would the remanent magnetisation there have?
- Also vertical (90^o)
- If a volcano erupted at the Equator, what dip would the remanent magnetisation there have?
- Horizontal (0^o)
- Some lavas of Carboniferous age in the UK have horizontal magnetisation. Where was the UK when the lavas erupted?
- On the Equator

Investigating Earth's structure

Preserving remanent magnetisation

Petri-dish magnetic field preserved in iron filings in wax © Michèle Bourne, ESEU



Magnetic inclination plotted against latitude (graph) © Chris King

Teaching Earthlearningideas

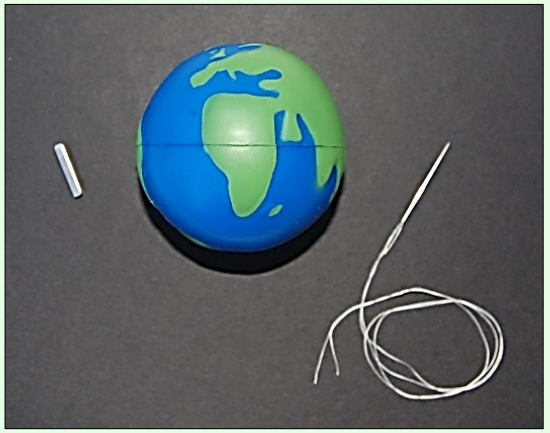
Earth's structure

- **Magnetic Earth using a sponge ball globe**

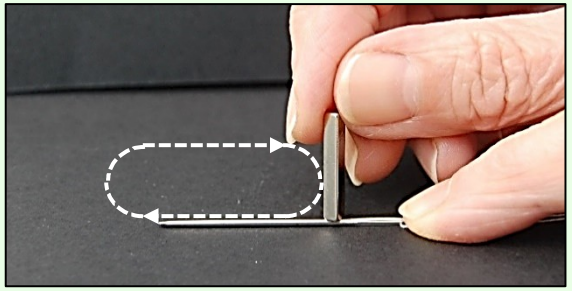
Go to: https://www.earthlearningidea.com/Video/V24_Magnetism3.html hyperlink

Investigating Earth's structure

Recipe for a magnetic Earth and a magnetic detector



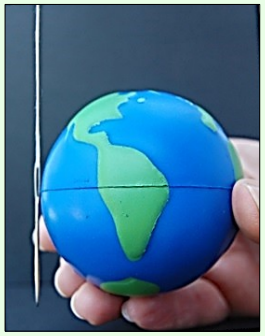
- Collect a needle and thread, a small magnet and an 'Earth' stress ball.
- Thread the needle with the piece of thread.
- Make the needle into a magnet, by laying it flat on the table, holding a magnet upright, and stroking it in the same direction ten times, as in the photograph.
- Push a sharp pencil or pen into the North Pole of the stress ball until it reaches just over half way
- Remove the pencil/pen and push a small magnet into the same hole until it reaches half way
- You now have a model magnetic Earth and a magnetised needle 'magnetic detector'



Investigating Earth's structure

Recipe for a magnetic Earth and a magnetic detector

- Find one of the magnetic poles of the Earth by hanging the needle from the thread, and finding where the needle is pulled straight down
- Find the pole on the other side of the model Earth, where the two magnets (the needle magnet and the one in the Earth) repel, so the needle is pushed away from the pole and circles around it at an angle
- Find the Equator, where the needle is upright beside the side of the Earth



Note: We need to teach pupils that Earth's magnetism is **NOT** caused by a bar magnet inside the Earth – the evidence is that it is caused by currents in the core. This is just a model of how Earth's magnetism works

Investigating Earth's structure

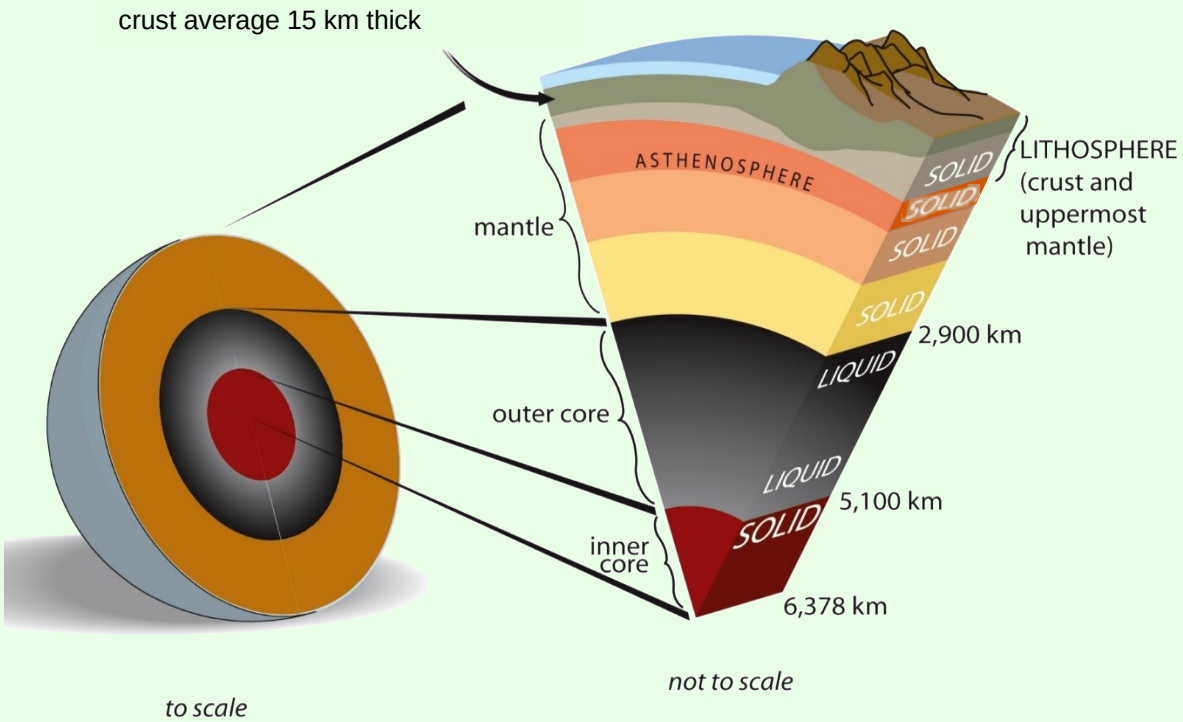
Workshop outcomes

The workshop and its activities provide the following outcomes:

- insights into the structure of the Earth and the dimensions of the Earth's layers;
- discussions and demonstrations about the state (solid/liquid) of the layers;
- the evidence we have for the dimensions and state of the layers;
- means of addressing common misconceptions about the Earth's structure;
- links to the science and geography of Earth's structure;
- guidance on how the elements of Earth science in the curriculum can be taught most effectively.

Investigating Earth's structure – online

Earth Science for science and geography – video workshop



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