

## A core activity

### Piecing together evidence for the composition of the Earth's core

Cut out sets of the 'Core evidence cards' below and give a set to each group of pupils. Ask them to sort the cards to show the evidence we have for the composition of the Earth's core.

Tell the pupils that the evidence may be on a single card, or a series of cards linked together, while some cards may contain no evidence for the core's composition.

When they have sorted their cards, ask them to suggest what the composition might be, and the evidence that supports this idea.

NB1: This activity focuses on the **composition** of the core and not its dimensions or physical state.

NB2: Densities are given in this activity as unit-less relative densities (ratios of density to that of water), so that pupils are not faced with complex density values, such as  $2.7 \times 10^3 \text{ kg m}^{-3}$ .



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*Cards on this sheet are not in numerical order.*

#### Core evidence card

We have no direct evidence of what is beneath the Earth's crust since no boreholes have drilled through the crust to the mantle. The deepest borehole ever drilled is 12 km deep; the distance to the outer edge of the core is nearly 3000 km. [1]

#### Core evidence card

Some volcanoes contain lumps of rock (xenoliths) that are believed to have come from the mantle; their density varies around 3.5. [5]

#### Core evidence card

The mean density of crustal rocks is about 2.7. [9]

#### Core evidence card

The mean density of the Earth, calculated by dividing its mass by its volume, is about 5.5. [12]

#### Core evidence card

The asteroid belt is a belt of objects between Mars and Jupiter; some may have come from earlier larger bodies which had cores, but were broken up by impacts. [2]

#### Core evidence card

Most meteorites appear to have come from the asteroid belt. [6]

#### Core evidence card

Most meteorites are stony meteorites, but there are also iron meteorites, formed mainly of nickel-iron. [10]

#### Core evidence card

The density of stony meteorites varies around 3 whilst nickel-iron meteorites have a density of around 7.5. [13]

#### Core evidence card

The density of the Earth is higher than that of any other planet in our solar system. [3]

#### Core evidence card

The density of iron is nearly 8 and the density of nickel is nearly 9. [7]

#### Core evidence card

The Earth's magnetic field reverses in polarity at irregular intervals. [4]

#### Core evidence card

Seismic P- and S-wave evidence shows that the distance from the surface to the outer edge of the core is nearly 3000 km. [8]

#### Core evidence card

Seismic S waves do not pass through the outer core, showing that it is fluid. [11]

#### Core evidence card

Calculations from the velocities of seismic waves show that the density of the core is between 10 and 13. [14]

## The back up

**Title:** A core activity

**Subtitle:** Piecing together evidence for the composition of the Earth's core

**Topic:** An activity asking pupils to examine and discuss the evidence for the composition of the Earth's core.

**Age range of pupils:** 13-18 years

**Time needed to complete activity:** 15-20 mins

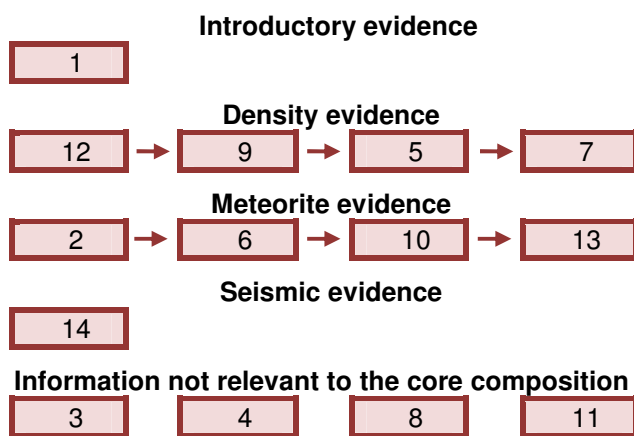
**Pupil learning outcomes:** Pupils can:

- explain that the evidence suggests the Earth's core is composed of nickel and iron;
- explain that the evidence for this composition comes from several sources;
- explain that the only evidence for the composition of the Earth's core is indirect evidence.

### Context:

Scientists cannot visit the Earth's core and so they cannot directly study what is down there. However there is a range of indirect evidence from meteorites, density measurements and geophysics to suggest that the core is composed of nickel and iron.

The cards can be arranged in a number of different ways – one method is as follows:



The suggestion by the pupils of what the composition of the core might be is their hypothesis, and the evidence they use, is used to support their hypothesis. This can be given verbally or in writing.

The amount of support offered to the pupils during the activity will depend on their age and ability.

Note that the densities given for iron and nickel on card [7] are not directly relatable to those of the core on card [14] because the density of the core is so high partly because of the great pressure affecting the materials of the core.

Note also that there is a widely-held misconception that one piece of evidence for the core being made of nickel-iron is that they are magnetic materials which cause the Earth's magnetic field. Even though they are magnetic, they are well above their Curie point (the point at which they lose their magnetism) and so could not cause a magnetic field. The Earth's magnetic field is caused instead, by movement of the electrically conducting liquid outer core.

### Following up the activity:

The activity can be extended to include the composition of the crust and the mantle so that students can use direct and indirect evidence to build up their understanding of the structure and composition of the Earth.

### Underlying principles:

- We can only directly observe the surface and near-surface of the Earth (near-surface in mines and boreholes); for deeper rocks, we have to rely on indirect evidence.
- The mean density of the Earth is about  $5.5 \times 10^3 \text{ kg m}^{-3}$  but the mean density of the crust is about  $2.7 \times 10^3 \text{ kg m}^{-3}$  and the density of the mantle is not much higher – thus the density of the core must be very high.
- Iron meteorites have a composition believed to be similar to that of the core; they have a density of around  $7.5 \times 10^3 \text{ kg m}^{-3}$  and a composition of iron with some nickel.
- Seismic evidence suggests that the core has a high density of between  $10$  and  $13 \times 10^3 \text{ kg m}^{-3}$ , partly caused by the great pressure (confining pressure) of the mass of the overlying materials, but also by the relatively high density of the core materials.

### Thinking skill development:

Construction is used to order the evidence cards while the cards which provide no evidence cause cognitive conflict. Pupil discussion involves metacognition.

### Resource list:

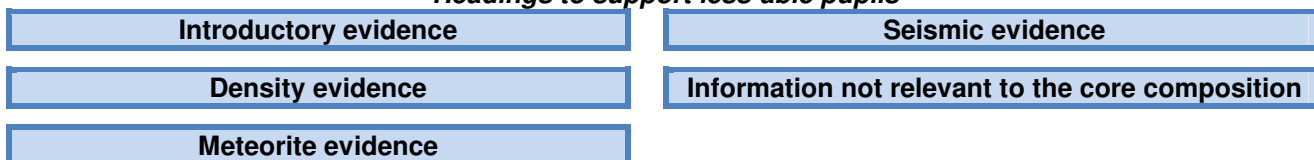
- a set of evidence cards for each group

### Useful links:

This links closely with the Earthlearningidea activity: 'From clay balls to the structure of the Earth'.

**Source:** Based on an activity designed by the science department of Congleton High School, Congleton, Cheshire, UK, modified by Keele University trainee science/geology teachers, Mike Parker, Lucy Pilkington and Emma Turner. Dave Rothery kindly provided advice on the scientific accuracy of this material.

### Headings to support less-able pupils



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