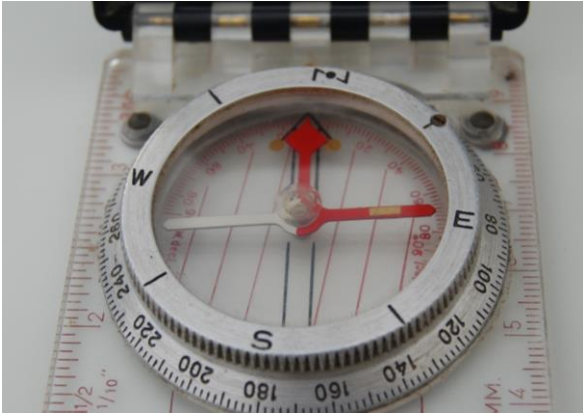


## Why won't my compass work on the other side of the Equator? Understanding the three-dimensional magnetic field of the Earth

A magnetic compass that works perfectly well north of the Equator, doesn't work at all on the south side of the Equator, as you can see in these photographs. In the same way, a compass that works in the Southern Hemisphere doesn't work north of the Equator.



A magnetic compass with a freely spinning needle in the Northern Hemisphere. (Photo: Chris King).



The same Northern Hemisphere magnetic compass photographed in the Southern hemisphere (Brisbane, Australia). (Photo: Chris King).

The second photograph shows the white end of the compass needle jammed down against the base of the compass, so that the needle can't rotate freely and it doesn't work.

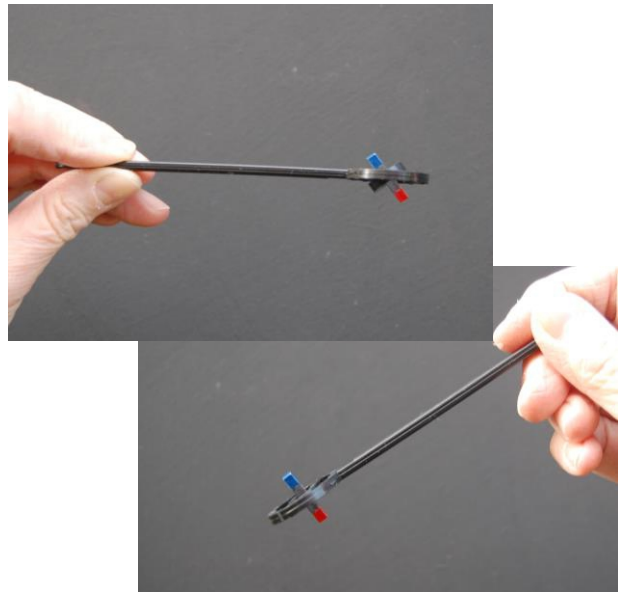
Show your pupils these photographs and ask them why this should be.

The answer is that a magnetic compass only shows the Earth's magnetic field in two dimensions because the needle has been weighted to float horizontally. If you want to measure the vertical part of the Earth's magnetic field, you need an instrument with a magnetic needle that rotates in the vertical plane, like the dip needle opposite.



A dip needle, with a magnetic pointer that rotates in the vertical plane to show the Earth's magnetic inclination. (Photo: Suzy Allen/Gwyn Jones)

However, the best way of showing the direction of the Earth's magnetism in the classroom is to use a magnet that is free to rotate in any direction, like the one in the Magnaprobe™ shown in these photos.



Photographs of a Magnaprobe™ showing that it doesn't matter how it is rotated. The magnet always points in the same direction because it is free to rotate in any direction. (Photos: Chris King).

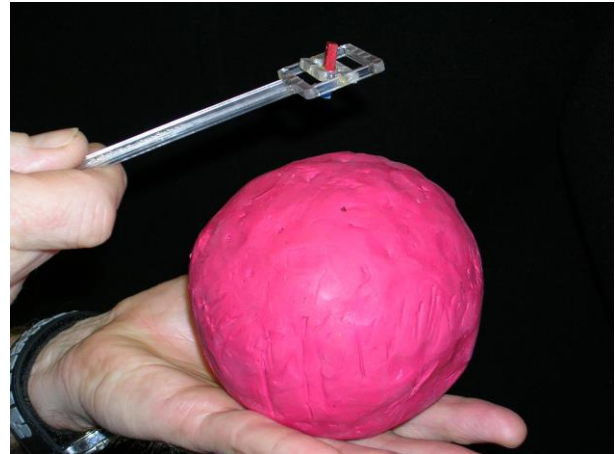
The freely-moving magnet shows the Earth's magnetic field in three dimensions. In the example in the photographs, the red end is the north-seeking end of the magnet so that, if you were looking horizontally along the line of the magnet towards the red end, you would be looking towards magnetic north.

However, the magnet is also pointing downwards (like the needle of a dip needle) since it is aligned with the three dimensional magnetic field of the Earth.

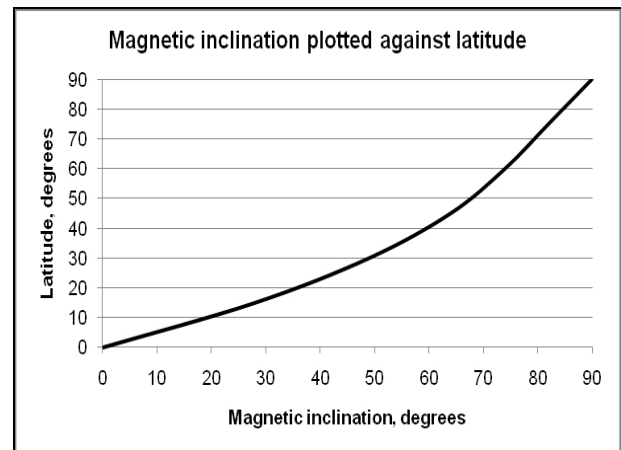
The 3D magnetic field of the Earth is best modelled using the 'Magnetic Earth: modelling the magnetic field of the Earth' Earthlearningidea. This uses a clay or Plasticine™ ball with a bar magnet hidden inside; a Magnaprobe™ is used to plot the magnetic field of the magnet hidden inside the ball.

When the ball is used as a model of the Earth, the Magnaprobe™ shows the three-dimensional shape of the Earth's magnetic field, which is vertically downward at the poles, horizontal at the Equator and dipping at various angles, depending upon latitude, between the Equator and the poles.

The 'Magnetic Earth: modelling the magnetic field of the Earth' and the 'Frozen magnetism: preserving evidence of a past magnetic field in wax' Earthlearningideas together explain how igneous rocks which are rich in iron minerals retain the angle of dip (inclination) of the Earth's magnetic field at the time of their cooling. This can then be used to work out the latitude of the rocks at the time when the rocks cooled using the 'Magnetic inclination plotted against latitude' graph opposite.



A Magnaprobe™ hovering above the North pole of a bar magnet, hidden inside a sphere of Plasticine™. (Photo: Peter Kennett).



## The back up

**Title:** Why won't my compass work on the other side of the Equator?

**Subtitle:** Understanding the three-dimensional magnetic field of the Earth

**Topic:** Using photographs of a magnetic compass working in one hemisphere, and not working in the other, to help pupils to understand the three dimensional magnetic field of the Earth.

**Age range of pupils:** 11-18 years

**Time needed to complete activity:** 10 minutes

**Pupil learning outcomes:** Pupils can:

- explain why a compass needle that floats horizontally in one hemisphere of the Earth dips downward and sticks against the compass baseplate in the other;
- use this explanation to describe the three-dimensional magnetic field of the Earth.

### Context:

People who take their magnetic compass from one hemisphere to the other are often surprised that it doesn't work in both. This activity uses this finding as a prompt to explain the three-dimensional nature of the Earth's magnetic field.

### Following up the activity:

Use the 'Magnetic Earth: modelling the magnetic field of the Earth' and the 'Frozen magnetism: preserving evidence of a past magnetic field in wax' Earthlearningideas together to plot the magnetic field of a model Earth and use it to explain how palaeomagnetism is used to calculate palaeolatitudes by reference to the graph above.

### Underlying principles:

- The Earth's magnetic field is three dimensional in the same way as the field of any magnet.
- It is because of the Earth's 3D magnetic field that the magnetic needle of a compass has to be weighted so that it floats horizontally in one hemisphere; but this means that the weight is on the wrong end of the needle for the other hemisphere, so that it doesn't work there.
- The vertical component of the Earth's magnetic field can be shown by a dip needle (constrained to rotate in a vertical plane) or a freely-rotating Magnaprobe™.

### Thinking skill development:

A full understanding of a magnetic field requires 3D spatial thinking skills.

**Resource list:**

- photographs of a working and a non-working magnetic compass, given above
- (optional) a magnetic compass – to show how this works normally
- a Magnaprobe™
- (optional) a dip needle

**Useful links:**

Put 'Earth's 3D magnetic field' into an internet search engine like Google™ to find a range of 3D images of the magnetic field of the Earth.

**Source:** Devised by Chris King of the Earthlearningidea Team.

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