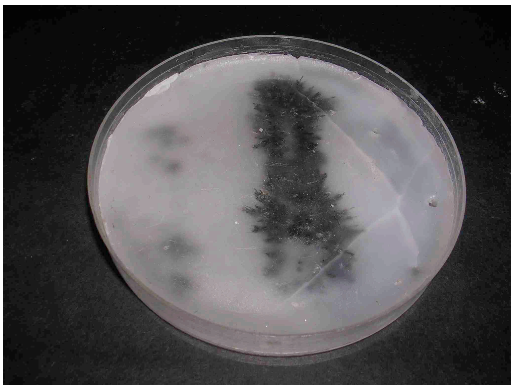
Frozen magnetism

Preserving evidence of a past magnetic field in wax

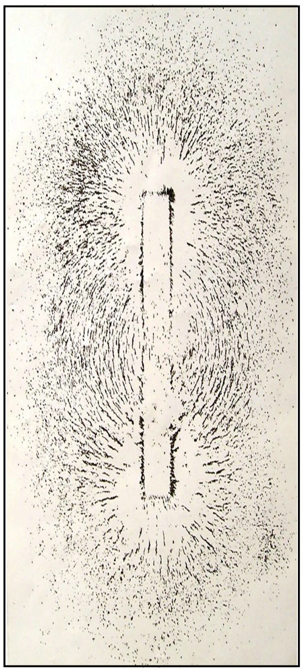
Many pupils are familiar with the activity where iron filings are shaken onto paper covering a bar magnet, to show the lines of magnetic force. In this activity, the evidence for the magnetic field may be retained, long after the magnet has gone. It also shows the three dimensional nature of the magnetic field.

Have ready a bar magnet and some iron filings in a "shaker", ready to scatter over the magnet. Melt some colourless wax in a suitable pot and pour it into a petri dish, or similar transparent dish until it is nearly full. Place the petri dish of molten wax over a bar magnet and shake the iron filings into it. Leave the magnet in place until the wax has set and then lift off the petri dish and show it to the class.

An alternative method is to place a piece of card over the bar magnet and shake iron filings onto it. Gently shake off any surplus and then spray the card with a clear lacquer from a distance of about 30cm. The card may be protected from damage by covering it with cling film.



The magnetic field around a bar magnet, shown by iron filings shaken into molten wax and allowed to set (Photo: *Peter Kennett*)



The magnetic field around a bar magnet, shown by iron filings shaken onto a piece of card and then fixed by spraying with a clear lacquer (Photo:*Elizabeth Devon*)

Ask the pupils:

a) if they can say which way the bar magnet was lying from the pattern of "frozen" iron filings;
b) if the iron filings can show which was the North pole and which the South pole, once the magnet has been removed;
c) if all the iron filings are lying parallel to the base of the petri dish, or if some are sticking up into the wax;
d) in what respects the pattern in the dish represents the magnetic field of the Earth;
e) whether the model shows that the Earth has a bar magnet within it or not.

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The back up

Title: Frozen magnetism

Subtitle: Preserving evidence of a past magnetic field in wax

Topic: A demonstration of how the evidence for the magnetic field around a bar magnet may be preserved, even after the magnet has been removed. This gives an analogy for the three-dimensional magnetic field of the Earth, with a North and a South Pole, but not for the origin of the Earth's magnetic field.

Age range of pupils: 11-18 years

Time needed to complete activity: 10 minutes plus 10 minutes to set up the wax model

Pupil learning outcomes: Pupils can:

- explain that a bar magnet has a North pole and a South pole;
- show that the magnetic field around a bar magnet is three dimensional;
- realise that evidence for a former magnetic field can be retained, after the source of the magnetic field has been removed.

Context: The activity can be used to aid the understanding of remanent magnetisation in rocks. This in turn provides evidence of past magnetic fields of the Earth and is of great value in demonstrating the former latitudes of the continents. Periodic reversals of the Earth's magnetic field are shown by the remanent magnetisation of rocks of the sea bed, which have been used to demonstrate sea floor spreading.

Responses to the questions to pupils posed above might include the following.

a) The position of the bar magnet is clearly indicated by the magnetic field pattern preserved in the wax, with iron filings pointing straight in at the poles but curving round until lying parallel to the long axis of the magnet at its mid point.

b) It is not possible to say which was the North and which the South pole, once the magnet has been withdrawn.

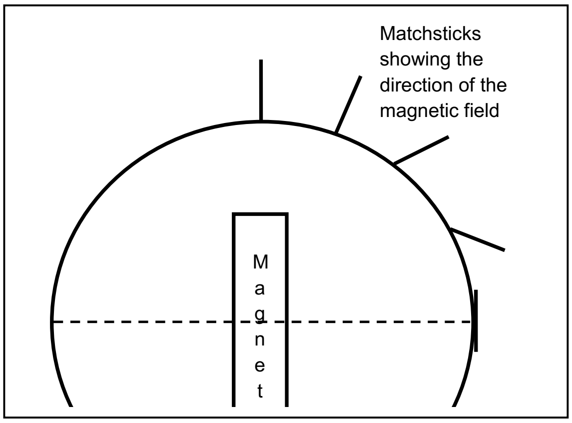
c) The dominant pattern in the iron filings shows the familiar two dimensional view, but there are also many filings which are standing up into the wax, showing that the magnetic field is **three** dimensional.

d) The magnetic field around the bar magnet is similar to that of the Earth in that it has both North and South Poles; that it is three dimensional; and that the dip of the magnetic field into both the bar magnet and the Earth is 90^0 at the poles, 0^o at the Equator and at varying angles in between.

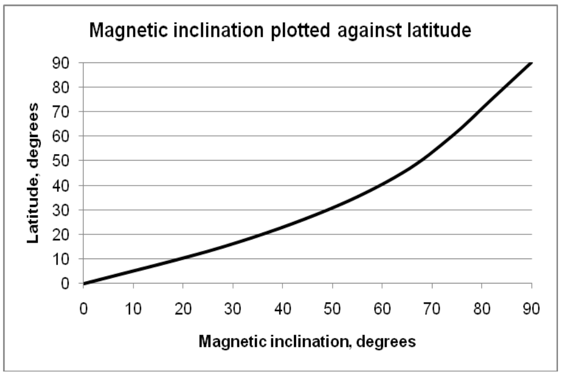
e) Modelling the magnetic field in this way does not imply that the Earth has a bar magnet inside it.

Following up the activity:

- Develop ideas of the three dimensional nature of the magnetic field by using a bar magnet encased in a sphere of modelling clay, to represent the Earth (See the Earthlearningidea activity "Magnetic Earth – modelling the magnetic field of the Earth").
- Show pupils the diagram of the variation in the angle of inclination (dip) of the magnetic field around a bar magnet inside a sphere – ranging from 90^o at the poles to 0^o at the equator (below) and ask them to relate this to the pattern seen in the wax model.



- Show pupils the graph of the relationship between magnetic latitude and geographic latitude (top, right).



Ask them to look up the geographic latitude of their own town in an Atlas and then to predict from the graph what the magnetic inclination would be. If a Magnaprobe™ is available, they could check the actual value. For example, at latitude of 56^oN the magnetic inclination would be about 71^o.

Underlying principles:

- The Earth has a magnetic field which is essentially bipolar.
- The Earth's magnetic field is probably caused by movements within the liquid iron-rich part of the outer core of the Earth and NOT by a bar magnet inside it.
- When some rocks containing magnetic minerals (particularly lavas) cool, they can retain the direction of the Earth's magnetisation at that location and at that time. This is called 'remanent magnetisation'. This information can then be used to work out the latitude of formation of geologically ancient rocks, at the time when they formed, in relation to the magnetic pole of the day.

Thinking skill development:

Pupils find the magnetic pattern marked by the iron filings. Relating the model to the real Earth is a bridging activity.

Resource list:

- strong bar magnet, (e.g. 7 cm long),
- a petri dish and enough colourless wax to nearly fill it **(or** a canister of clear lacquer and a sheet of card)
- a source of heat and a container in which to melt the wax
- iron filings in a shaker
- *for following up the activity* - a Magnaprobe™ (a tiny magnet suspended in gimbals in a plastic frame)

Useful links:

'*Magnetic Earth – modelling the magnetic field of the Earth*' activity from Earthlearningidea, www.earthlearningidea.com
http://www.cochranes.co.uk/show_category.asp?id=50 for the supply of the Magnaprobe™.

Source: Based on the workshop titled "The Earth and plate tectonics", Earth Science Education Unit, http://www.earthscienceeducation.com