Earth’s Magnetosphere- Teacher Notes

Earth is surrounded by a magnetic field (magnetosphere) like a simple dipole (two pole) magnet. This can be inferred by its effect on magnetic materials and also by the deflection of cosmic radiation.

Artificially magnetised iron results from the alignment of the outer skin of electrons that surround its positive core. It occurs naturally as magnetite (Fe_3O_4). Magnetism can be induced in the laboratory by wrapping a sensitive metal with a coil carrying an electric current and conversely moving magnets can induce electric current in a wire. A magnetic field is the area of field around a magnet.

The magnetic field surrounding the Earth is probably the result of a different process. The outer layer of the core acts like a giant dipole magnet due to electric currents in the molten pressurized iron and nickel. This explanation is known as the ***“Dynamo Theory”***. The movement of its internal conductive plasma produces the Earth’s magnetic field.

Because the conductive fluid dynamo that powers this field is quite “chaotic” both the Sun and Earth’s fields are subject to polar wandering and polar reversals. The Sun’s field reverses every eleven years and the Earth’s poles reverse every 200,000 to 300,000 years. Interestingly our next reversal is overdue and is calculated to happen within the next 2,000 years.

Earth’s magnetic field, or magnetosphere acts as a shield against cosmic radiation. It deflects the stream of charged particles emanating from the upper atmosphere of the Sun.

The molten iron rich rock, solidifying at the surface, takes on the orientation of the poles at the time of crystallisation.

Earth’s magnetism and its effect on magnetite was used by early navigators. They would float fragments of magnetite (Fe_3O_4) on paper or parchment over a liquid and it would move to align with magnetic North. Since it helped “lead” them to where they wanted to go, magnetite’s common name is “lodestone”. Students may try this using a pin or needle inserted through paper. Paper increases the surface area of the needle, decreasing its pressure and maintaining surface tension. In time paper will absorb water, become denser and sink. The “Make Your Own Compass” activity explains this.

In Western Australia early explorers had problems with major iron rich rock formations deflecting their compasses. Indeed the presence of magnetite in some parts of the Goldfields makes compasses unusable. Later prospectors used this effect to delineate greenstone belts containing magnetite and pyrrhotite. They did not seek those minerals, rather the magnetically unresponsive gold which was often found with them. How Mount Magnet in the Goldfields got its name should be self-evident. The Surveyor Robert Austin noted in 1854 that a hill near the present town site had magnetic iron stone which played havoc with his compass.

Geophysicists use variations in the Earth’s magnetic field to find ore deposits. They fly magnetometers over prospective areas. By raising the height of the magnetometers they can penetrate through our regolith (blanket soil) to the deeply buried ore deposits below.

An initiative supported by Woodside and ESWA

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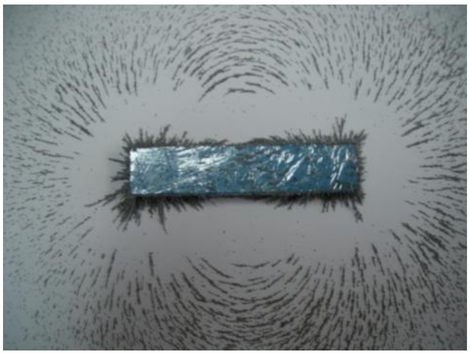
When magnetic minerals crystallise from molten magma they will align themselves with Earth’s magnetic field at that time. Molten mafic magma such as basalt and dolerite will keep this imprint of the magnetic north pole until they re-melt. They register both the direction and dip. From this data both latitude and longitude of the place of crystallisation can be inferred.

Materials per student or group

- Two dipole bar magnets
- Scrap paper
- Kitchen plastic film (Glad wrap or equivalent)
- Iron filings (preferably in a shaker)

Wrap one magnet tightly with plastic.
Place on a piece of scrap paper.
Sprinkle iron filings across the magnet.
Observe and draw what you saw in the worksheet provided.

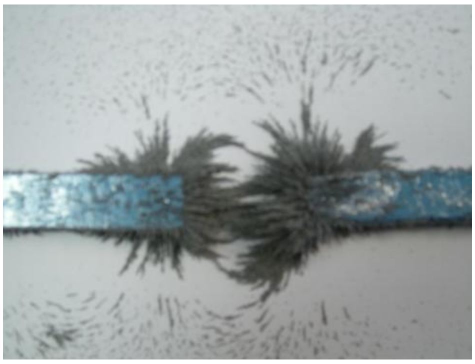


Magnetic field around a dipole magnet

Can you see the sphere of magnetism around the magnet? No. It can only be inferred by its effect on the iron filings.

Place another sheet of paper over the magnet and sprinkle filings over its surface.
What can you infer? Although you cannot see the magnet its presence can be inferred by the pattern of the iron filins.

Loosen the filings by unwrapping the magnet and retain the filings in the wrap.
Wrap both magnets.
Place magnets with like poles (N & N or S & S) 1cm apart and sprinkle with filings
Observe and draw what you saw in the worksheet provided.



Magnetic field around two like poles

Earth’s magnetic field is not due to an internal magnet but is probably created by the rotation of the inner solid nickel iron core within the liquid outer core. Since the field is driven by movements in the core the magnetic poles are not in the same location as the geographic poles, wander and can even reverse, over time.

Interesting Fact: When working near the magnetic poles, a simple compass is not used as the declination of the needle towards the centre of the Earth is too steep to permit free rotational movement.

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Interesting Fact: Magnets were called 'lodestones' because they could lead you to the correct path by pointing north.

How do the magnetic poles differ from the geographic poles?

Geographic poles are stationary and indicate 0^0 latitude. They do not reverse or "wander".

Magnetic poles move because of changes in the Earth's core and as a result of earthquakes. They wander and reverse.

EXTENSION

Approach one magnet with the like pole of another magnet.

I observed the magnets felt forced apart

Then approach one magnet with the opposite or unlike pole of another magnet.

I observed the magnets felt pulled together

Rules for magnets

LIKE POLES (N and N or S and S) repel

UNLIKE POLES (N and S) attract

Legend has it that the Greek scientist Archimedes used lodestone to pull nails from enemy ships and sink them! Do you think this is true? No he would need to have an extremely strong magnet. I have tried this repeatedly with iron nails hammered into pine and it did not work

Is the magnetosphere spherical? No because it forms a long tail pointing away from the Sun because of the "solar wind" a stream of photons blasted out from the sun.