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News

## Core business



A cutaway, showing Earth's core. Adapted image, original courtesy of [NASA](#)

If you have ever wondered how come we can use a compass to find our way, you probably imagined that there is an enormous magnet at the centre of the Earth, fortuitously pretty much aligned with the axis around which the Earth spins. In fact, this cannot be so, because although the Earth's core consists largely of iron, its outer part is liquid and its inner part is extremely hot (around the temperature of the surface of the sun). And magnetic fields don't last long in liquids or at extremely high temperatures. In fact, the existence of a largescale geomagnetic field has long been seen as something of a mystery.

Even more mysterious has been the fact that the field has in the past varied in strength and orientation, and has even reversed polarity many times. We can tell this from the alignment of small iron particles in layers of rock on the ocean floor and in ancient lava flows.

Now a group of scientists led by Gauthier Hulot of the Institute of Earth Sciences in Paris have announced that over the last twenty years, the geomagnetic field has declined in strength by around 10% – if this rate continues the field will be completely gone by early next millennium. They speculate that we may be in the early stages of a polarity reversal.

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By comparing images of the Earth's magnetic field taken in 2000 with ones taken in 1980, they have discovered that the reason for this decline is that areas of reversed magnetic flux – the main one is beneath the southern tip of Africa – are currently growing rapidly in size.

Such a polarity reversal could have severe consequences, because while it is happening the field will be weak or nonexistent. Normally it protects us from cosmic radiation, and may even play a part in preserving the Earth's atmosphere.

So if a giant lump of magnetic iron in the centre of the Earth isn't responsible for the geomagnetic field, then what is? By far the leading theory is that currents in the fluid outer core, started by the temperature differential between the mantle (crust) and the core, and organised into predominantly helical flows by the spinning Earth, act like a giant *dynamo*.

Maxwell's equations describe the dynamo effect – that electric currents give rise to magnetic fields, and moving magnets generate electric currents. (In effect, magnetism and electricity are different manifestations of the same phenomenon, usually referred to as "electromagnetism".) The flows in the outer core amplify a small "seed" field captured from the Earth's surroundings as it formed. A positive feedback effect comes into play, with flows of slightly magnetised iron setting up electric currents, which in turn create more magnetism, and so on until the magnetic field becomes strong enough to influence the fluid flows, at which point the magnetic dynamo produces a self-sustaining field.

We're probably most familiar with dynamos in the guise of battery-free bike lights. These contain a magnet and are attached near to the bike wheel. As you pedal, the motion of the wheel turns the magnet, creating an electrical current which is used to power the light.

Over 99% of the Earth's magnetic field is confined to the core, where the complexities of the fluid flow means that there are constantly changing smaller magnetic fields, which may be aligned differently from the large-scale geomagnetic field. Some of these seem to be growing very fast right now, and it is speculated that a positive feedback effect could amplify them till they cause the current north-south dipole to break down entirely.

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*Plus* is part of the family of activities in the Millennium Mathematics Project, which also includes the NRICH and MOTIVATE sites.