Scientists shed light on magnetic mystery of graphite

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The physical property of magnetism has historically been associated with metals such as iron, nickel and cobalt; however, graphite – an organic mineral made up of stacks of individual carbon sheets – has baffled researchers in recent years by showing weak signs of magnetism.

The hunt for an explanation has not been without controversy, with several research groups proposing different theories. The most recent suggestion, published today, January 27, in the journal *EPL* (*Europhysics Letters*), has been put forward by a research group from the University of Manchester that includes Nobel prize-winning scientist Professor Sir Andre Geim.

The research group, led by Dr Irina Grigorieva, found that magnetism in many commercially available graphite crystals is down to micron-sized clusters of predominantly iron that would usually be difficult to find unless the right instruments were used in a particular way.

Finding the way to make graphite magnetic could be the first step to utilising it as a bio-compatible magnet for use in medicine and biology as effective biosensors.

To arrive at their conclusions, the researchers firstly cut up a piece of commercially-available graphite into four sections and measured the magnetisation of each piece. Surprisingly, they found significant variations in the magnetism of each sample. It was reasonable for them to conclude that the magnetic response had to be caused by external factors, such as small impurities of another material.

To check this hypothesis, the researchers peered deep into the structure of the samples using a scanning electron microscope (SEM) – a very powerful microscope that images samples by scanning it with a beam of electrons – and found that there were unusually heavy particles positioned deep under the surface.

The majority of these particles were confirmed to be iron and titanium, using a technique known as X-ray microanalysis. As oxygen was also present, the particles were likely to be either magnetite or titanomagnetite, both of which are magnetic.

The researchers were also able to deduce how many magnetic particles would be needed, and how far apart they would need to be spaced in order to create the originally observed magnetism. The observations from their experiments agreed with their estimations, meaning the visualised magnetic particles could account for the whole magnetic signal in the sample.

Dr Grigorieva, said: "The excitement around the findings of ferromagnetism in graphite, i.e. pure carbon, is due to the fact that magnetism is not normally found in organic matter. If we can learn to create and control magnetism in carbon-based materials, especially graphene, this will be an important development for sensors and spintronics."

More information: The published version of the paper "Revealing common artefacts due to ferromagnetic inclusions in highly-oriented pyrolytic graphite" Grigorieva et al 2012 *EPL* 97 47001 is freely available from iopscience.iop.org/0295-5075/97/4/47001

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