Landmark discovery has magnetic appeal for scientists

December 21 2011

A fundamental problem that has puzzled generations of scientists has finally been solved after more than 70 years. An international team of scientists has discovered a subtle electronic effect in magnetite – the most magnetic of all naturally occurring minerals – causes a dramatic change to how this material conducts electricity at very low temperatures.

The discovery gives new insight into the mineral in which mankind discovered magnetism, and it may enable magnetite and similar materials to be exploited in new ways.

The research, published in *Nature*, was led by the University of Edinburgh in collaboration with the European Synchrotron Radiation Facility (ESRF) in Grenoble, France, where the experiments were conducted.

The magnetic properties of magnetite have been known for more than 2000 years and gave rise to the original concepts of magnets and magnetism. The mineral has also formed the basis for decades of research into magnetic recording and information storage materials.

In 1939, Dutch scientist Evert Verwey discovered that the electrical conductivity of magnetite decreases abruptly and dramatically at low temperatures. At about 125 Kelvin, or minus 150 degrees Celsius, the metallic mineral turns into an insulator. Despite many efforts, until now the reason for this transition has been debated and remained

controversial.

When the team of scientists fired an intense X-ray beam at a tiny crystal of magnetite at very low temperatures, they were able to understand the subtle rearrangement of the mineral's chemical structure. Electrons are being trapped within groups of three iron atoms where they can no longer transport an electrical current.

Dr Jon Wright of the ESRF said: "Our main challenge was to obtain a perfect crystal, which meant using one that was tiny, just half the diameter of a human hair. Then we needed to observe subtle changes in this microscopic sample as we lowered the temperature. In Europe, this is only possible at the ESRF, thanks to the extremely high energy of its synchrotron X-rays."

Professor Paul Attfield, of the University of Edinburgh, said: "We have solved a fundamental problem in understanding the original magnetic material, upon which everything we know about magnetism is built. This vital insight into how magnetite is constructed and how it behaves will help in the development of future electronic and magnetic technologies."

Provided by University of Edinburgh