Rare rocks for new challenges

The not so scarce rare earth elements are an intrinsic part of many new, green technologies. Their uses span a wide spectrum, but their availability for the future may be uncertain.

RARE EARTH ELEMENTS are a group of metals that encompass the 15 lanthanides as well as yttrium and scandium. Their mining and production, for the most part, began to rise in the 1960s due to their use in cathode ray tube technologies in some of the first colour televisions. In the last 20 years or so, their popularity has exploded again as the repertoire of electronic technologies pervading modern life – including tablets, mobile phones and laptops among others – has escalated. Alongside this, they are expected to become increasingly important as the range of green technologies expands.

IT'S NOT ALL IN THE NAME

Despite the name, a number of rare earth elements have a similar crustal abundance to many traditional industrial materials like nickel and lead. The most scarce of the rare earth elements are still 200 times more abundant than gold. However, they tend to be available at low concentrations in a particular area, making it economically unviable to extract them. China has an estimated 50 per cent of known rare earth reserves and for a long time has dominated the rare earth element market, but now the US and Australia have begun extracting them again.

These elements have an unusual and diverse complement of properties including catalytic, electrochemical, magnetic and optical. These characteristics lend themselves to a host of present and future applications.

FUTURE TECHNOLOGIES

With their incredible properties, rare earth elements are expected to be used in many new technologies. Several of the rare earth elements have large magnetic moments and alloys of gadolinium display a huge magnetocaloric effect, whereby an external magnetic field can affect the temperature of the material. Most recently, one of the newest applications proposed has been magnetic refrigerators, widespread use of which could cut energy consumption and carbon dioxide emissions dramatically, as well as eliminate the need for toxic and ozone-depleting chemicals. This incredible effect could therefore be exploited to replace less efficient gas-compression refrigeration.

Taking advantage of the magnetocaloric effect in praseodymium, scientists have been able to coax the material to temperatures close to absolute zero using applied magnetic fields. This gives the material potential as a new superconductor able to conduct electricity with zero resistance below certain temperatures; an extraordinary property. Praseodymium has also been used by scientists to create revolutionary ‘slow light’. At the Rowland Institute for Science, Massachusetts, in 1999, scientists successfully slowed light
to 38 miles per hour. Although a staggering achievement, most likely practical applications are far off. IBM has taken up research on this phenomenon, however, as a highly efficient method of transmitting data in computers.

Lanthanum compounds have been used to produce carbon nanotubes and semiconductors. Carbon nanotubes are an astoundingly strong and light technology, which could have applications from healthcare to electronics. Similarly semiconductors, with doping with different compounds, can adopt a range of useful properties.

WILL SUPPLY MEET DEMAND?

As the number of technologies using rare earth elements multiplies, there is growing concern that modern society will become too reliant on these materials. This is especially a worry as the use of green technologies, which require large amounts of these difficult to extract materials, is expected to increase as humanity aims to reduce environmental impacts. As an example of how huge these increases may be, a study in 2012 predicted neodymium and dysprosium demand will rise by 700 and 2,600 per cent respectively in the space of 25 years.

Additionally, the market is still largely dominated by China, so there is a need for increased variety of suppliers. It is highly likely that prices of these metals will rise as supply begins to drain away, and this will add to the factors that stand in the way of more widespread use of greener technologies. It came as a huge shock, but also a tangible premonition of what may come, when in 2011 the average rare earth metals’ price increased by about 750 per cent in the space of one year due to environmental concerns. One main difficulty is that, due to the metals’ unique properties, it is often difficult to replace their function with more accessible materials. However, we can expect that with sufficient research, more sustainable solutions may be found to the problems that these special materials have solved.