STRATEGICALLY IMPORTANT METALS

Mark Tyrer and Alan Gibbon present their views a year after the Science and Technology Committee report

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MIRO – The Mineral Industry Research Organisation is a not for profit limited company owned by its members and based in the UK.

In May 2011, the Parliamentary and Scientific Committee discussed strategically important metals. At that time, the findings of Science and Technology Committee had just been published (HC 726), to which the formal government response was issued in September (HC 1479). These and the many commissioned studies considering this topic, form a substantial body of work which describe our reliance on certain elements, their supply chains, applications and recovery. In the year which has passed, we consider some of the recommendations of this work and look at how they might be implemented.

The issue is that for many technologies, reliance on a limited number of chemical elements is absolute, or almost so; in that no alternative approaches have yet been developed which would displace them. There are many examples, prominent amongst which are the use of the rare earth elements (REE, lanthanides) dysprosium, terbium and especially neodymium in modern 'super' magnets and the use of lanthanum in battery technology. Beyond REE metals, many other examples exist, such as phosphorous and fluorine for the chemicals and allied industries, indium in computer displays and the platinum group metals. For example, applications for ruthenium have burgeoned in recent years, owing to its incorporation in electronics (hard disk drives, on-chip resistors) and in display technology. In recent years, the supply of many strategic metals has been controlled by China, whose reserve of rare earths eclipses the rest of the world. Understandably, it is of greater benefit to China to export value-added products rather than raw materials and this is the underlying driving force of the debate.

In looking for alternative sources of supply, world attention has focused on Australia, South Africa and the United States, all of which have capacity to expand their production, and are in the process of doing so now the global demand (and price) of scarce materials has risen. The *Mountain Pass* mine in south east California is expected to regain its full production capacity later this year and other countries are responding to growing demand, estimated at between 8 and 11% per annum.

We might ask what resources are available to us in the UK; do we have reserves of REE and other minerals which we might exploit? The S&T report cites written evidence from the Mineralogical Society and the Royal Society of Chemistry which states that the UK mineral reserves are incompletely known, referring to the *Mineral Reconnaissance Programme* led by the British Geological Survey (BGS) which has identified unexploited deposits of various strategic metals, such as the platinum group metals and gold, in the UK. Through support from the Natural Environment Research Council (NERC) BGS compile and publish 'World Mineral Production', as well as production and trade data for Europe. In addition, BGS publish the 'Mineral Commodity Profiles' which include strategic metals such as REEs, tungsten and PGMs – a new one on Li will be published later this year. The NERC Knowledge Exchange Grant is funding a new 'Critical Metals Handbook' from BGS which is expected at the end of the year. Written evidence from the Geological Society discusses resource recovery from secondary mineral sources such as burnt oil shale waste, fly ash and metallurgical slags, which has attracted considerable attention. Andrew Miller MP, Chaiman of the S&T Committee, said *"There is significant potential for the UK to improve its efficiency of metal use, and we heard evidence of effective methods for materials recovery. It is vital that the Government explores these options without delay."*

As to what government actions are being undertaken as a result of the debate, DEFRA and BIS summarise new initiatives in their recent 'Resource Security Action Plan' (March 2012) as follows:

- Innovation Challenge: Defra will fund an Innovation Challenge Fund for local economy closed-loop projects under the co-ordination of the TSB. The

idea is that local businesses will be helped to extract value from domestic and commercial waste streams, through partnerships between business, local authorities and local communities.

- The government (through BIS) will investigate the feasibility of applying the principle of Individual Producer Responsibility (IPR) more generally to the Waste Electrical and Electronic Equipment (WEEE).
- Similarly through BIS, the government will work to support UK businesses by extending data capture of waste electrical and electronic equipment being treated by waste management companies and other players outside the current 'WEEE system'.
- The Environmental Sustainability Knowledge Transfer Network (ES KTN) together with the British Geological Survey and other partners including the Waste and Resources Action Programme (WRAP), BIS, and Defra will develop and test a 'critical resources dashboard'. This will seek to provide companies with better information to take more informed decisions on the resource risks to their operations, and will be launched by the end of January 2013.
- WRAP will develop a high level critical materials flow analysis in key WEEE product categories (initially for WEE 'hotspots').
- A new industry-led consortium, convened by the Green Alliance, will bring together interested businesses and business groups to provide a mechanism to develop further links between government, business and other organisations to address resource opportunities and concerns, to disseminate leadership thinking and best practice and to provide a forum for policy innovation.

Whilst each of these initiatives is to be applauded, there seems to much fundamental work still to be done. High on the list would be to prepare for growth in strategic metals recycling.

Although some of these elements are not especially rare, rich ores of these elements are very scarce and many commercial deposits are in a few, fairly remote locations. To compound this, relatively small quantities are in current use, of which only a small fraction is in products close to the end of their service lives. Consequently, recycling of these metals is in its infancy. Compare this situation with that of lithium, which although more abundant, is not yet recycled effectively. On a recent visit to the lithium operations of *Umicore*, in Olen, Belgium recently, our host asked a simple question – *"What have you done with your old mobile phone?"* Without exception, the visitors admitted that they were in a drawer with several others! This is a key hurdle which we must overcome and the solution is not a simple one. There is a considerable time lag between acquiring technology containing scarce resources and our willingness to recycle them and the same is likely to be true of other rare metals. It seems likely that many expensive devices will be stored at the end of their lives – 'just in case they are needed – before they enter the recycling circuit. To impose a tax on new electronic devices to be refunded upon recycling seems a draconian measure, but surely, some incentive is needed to promote resource efficiency.

One of the difficulties of dealing with the lanthanides is that they exhibit such similar chemistries. This makes their chemical separation notoriously difficult and expensive, which has resulted in renewed interest in separative technology such as electro-winning of the metals from molten salts. Fundamental to this is our incomplete understanding of the chemical thermodynamics of these elements and their compounds, without which, industrial optimisation of process chemistry becomes a rather slow and vague process. The National Physical Laboratory has recently launched a 'Rare Earths Club' as a way of drawing together expertise in this field. An ability to predict the optimum conditions for metal separation would put the UK at the forefront of REE recycling.

The Research Councils have a key role to play in developing this technology. The Engineering and Physical Sciences Research Council (EPSRC) are building on their recent projects on REE recycling with a transatlantic call for proposals with the (US) National Science Foundation. Specifically, one task seeks proposals in *"New chemistry to recycle economically chemicals that cannot be replaced, such as phosphorus and the rare earth elements".* The Natural Environment Research Council (NERC) has launched two recent programmes: *'Mineral resources: Science to sustain security of supply in a changing environment' (£7m, contributes to sustainable use of natural resources theme).* This recognises the need for rapid advances in science to understand how strategic minerals are mobilised and concentrated in the earth's crust and the technologies required for their location and efficient recovery.

It is very encouraging to read of the NERC companion programme *"Resource recovery from waste (£6m, Contributes to sustainable use of natural resources and environment, pollution & human health themes)".* Recycling research impinges on the activities of both EPSRC and NERC and it is heartening to see this activity embraced directly. This programme seeks *'to lead the delivery of the strategic science needed to accomplish a paradigm shift in the recovery of resources from waste, driven by environmental benefits integrated across air, soil and water resources and for human health, and not by economics. Further, the programme will forge new thinking that goes "beyond carbon" to understand waste as a resource from the perspective of ecological not carbon outcomes.'*

Hear! Hear! So often we see technological developments hampered by the economic constraints of immediate financial return. The nation needs to invest in generating knowledge and understanding before planning commercial developments. Our traditional approach of good at 'R' but less so at 'D' need not persist. In the case of REE recycling, wealth generation may reasonably follow knowledge generation, if we manage our knowledge resources with care.

This subject needs a champion. The activities reported here are an excellent start, but they need to be focused on the national need if momentum is to be maintained. Perhaps the S&T committee will revisit this subject in a couple of years time, to show the real advances made from this strong start.