Elements in short supply

In a special issue this month we explore the challenges caused by supply shortages of several important chemical elements.

When we think of scarce natural resources, the availability of oil is the main one that comes to mind. Indeed, this year has seen rising oil prices that recovered from a dip to US$40 per barrel, and for the first time in two years again have exceeded US$100 per barrel. Oil is becoming difficult to produce with rigs being placed at increasingly challenging locations.

However, what has recently become clear is that many other key materials are in danger of becoming unavailable. The key difference is, however, that oil is a molecule that is valuable for the energy stored in it, and not for its carbon and hydrogen atoms. Many of the scarce materials on the other hand are valuable because of the chemical elements they contain.

The group of materials that has been widely in the news are the rare-earth elements, many of whose prices have more than tripled over the past year. As Alexander King, director of the Ames Laboratory in Iowa, US, says in his Interview[1], prices will continue to rise. China, who mines 97% of the global rare-earth metal supply, now requires a significant amount of these elements for its own domestic production. At the same time global demand is also set to rise, making price hikes inevitable.

A good example of this problem is that of the rare-earths neodymium and dysprosium. Some of the most powerful yet small and lightweight permanent magnets are made of neodymium iron boron, mixed with small quantities of dysprosium to enhance their operation temperature. These magnets are used in computer hard drives, in the electro motors of the increasingly popular hybrid and electric cars, as well as in wind turbines.

The problem with these rare earths is not so much that these elements are scarce, but that the cheap prices of the ores coming out of China has squeezed any competition out of the market. The inevitably rising commodity prices will counter this trend, and other mines outside China are in the process of being started again. However, until these are operational prices will continue to rise, possibly quite dramatically.

Unfortunately, rare earths are not the only scarce chemical elements that are of concern[2]. Tellurium, which is used in solar cells, is mined along with the commercially far more attractive copper. As King also points out in his Interview, at present it is not commercially attractive to produce small quantities of tellurium in favour of the much larger copper market, in particular as copper prices have also risen by more than 50% last year. Unless of course tellurium prices follow that trend and adjust accordingly.

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Rare-earth magnets being recycled at Hitachi.

There are two reasons for chemical elements to become scarce. Some, like tellurium, are simply not that abundant anywhere in the Earth's crust, whereas others are found in only a few places, which might create political issues for their supply. China's dominance on rare earths falls into that category, or Bolivia's and Chile's vast resources of lithium, which is used for rechargeable batteries. And the known global reserves of niobium, which is abundant and used for steels and other alloys, are almost entirely located in Brazil.

What are the lessons from these projected shortages? Certainly that we need to be more proactive. One of the first countries to realize such upcoming shortages of elements was Japan — a country without such natural resources and therefore highly dependent on their availability. In his Commentary, Eiichi Nakamura from the Chemistry Department at the University of Tokyo describes some of Japan's initiatives to combat the scarcity of resources[2].

We need to recognize that this is an issue that affects a broad range of technologies. The rare earths alone are important in areas that span from clean energy to lasers and telecommunications, where erbium is a key element for optical fibre technology.

Once critical areas are identified, we need to manage our resources better. In some instances it could simply mean to intensify mining. For scarce elements it may also mean to better manage their consumption. Crucial is to reuse and recycle where possible. The use of rare earths in electronic gadgets has risen so much that their concentration in computers is actually higher than that in mines. It pays to recycle.

Eventually, market forces will of course even out such imbalances in supply and demand. However, in the short-term price hikes and supply problems can lead to considerable distortions of these markets. In the long-term, we need to be more aware of the issue and be more careful in the managing of our natural resources.

And this is not only for the benefit of securing technological progress. The supply of phosphorus, which as an element is actually not very rare, comes entirely from mining, with large reserves in the Middle East and in China. Phosphorus is not only important for example for detergents, but also as a fertilizer for plants. And although at present there is no fundamental shortage of phosphorus, with the continuing growth of the human population and the advance of biofuels resources might quickly be running out. With our own bodies being crucially dependent on phosphorus it is to be hoped that by then we are better equipped in managing shortages of chemical elements. ❐

References

1. *Nature Mater.* **10,** 162–163 (2011).
2. http://minerals.usgs.gov/minerals/pubs/commodity/
3. Nakamura, E. *Nature Mater.* **10,** 158–161 (2011).