Unsporting scandium

From Earth to the stars and back again, **John Emsley** surveys the uses, occurrences and mysteries of an element that is playing an increasing role in human affairs.

When Dimitri Mendeleev first presented his periodic table in 1869, he did so noting that there were larger than expected differences between the atomic weights of several elements, and left gaps for them. One such gap was between calcium and titanium, and from this he speculated that there should exist a metal with an atomic weight of approximately 44 — which he called 'ekaboron'. Just ten years later, Lars Fredrik Nilson at the University of Uppsala was analysing the brown lustrous mineral euxenite — which actually contains no fewer than eight metals — when he found that a metal extracted from it exhibited lines in its atomic spectrum that had not been previously reported. This metal, whose atomic weight he calculated to be 44, was indeed the missing element anticipated by Mendeleev. Ekaboron is not to be found in modern-day periodic tables though, as Nilson named his newly discovered element 'scandium' after the Latin for Scandinavia.

On Earth, scandium is not particularly abundant, and is found in similar quantities to lead. Unlike lead, however, it is widely dispersed throughout the Earth's crust because there are no geological processes to concentrate it, which is why it is present in small amounts in hundreds of minerals. Minerals made purely of scandium compounds are highly prized by collectors. Samples of the greenish-black thortveitite ($Sc_2Si_2O_7$) from Iveland in Norway were worth more than their weight in gold at some points during the 1950s, and a specimen less than 10 cm in length is currently on the market for $1,500. There are samples of thortveitite of such crystalline purity that they have been cut as gem stones, which may explain why similar specimens fetch such a high price.

The strong lines in the atomic spectrum that enabled Nilson to first identify scandium also allow its relative abundance in stars and the interstellar medium to be probed. In 1908, Sir William Crookes used these spectra to report that scandium is, unexpectedly, more abundant in other stars than in our Sun. This stellar anomaly is still being studied, as is a curious scandium-rich nebula that surrounds the Eta Carinae star system 8,000 light years away. It has been observed over the centuries to brighten and dim quite inexplicably[1], and the role of scandium in this observation is still under investigation.

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Although its function and fate in interstellar space has yet to be clarified, scandium has no role in the biosphere on Earth, and no living organism has yet been found that requires it. Only minute traces of scandium enter the food chain and the average person's daily intake is likely to be less than a tenth of a microgram. Rather strangely, tea leaves contain comparatively more scandium than other plants — although, as this is on average only 140 ppb, tea lovers need not be concerned. One explanation for this unusual concentration is that tea bushes do not discriminate between absorbing chemically similar aluminium — which they are known to require — and scandium.

Even though there are no scandium mines, and so it is only extracted as a by-product of tantalum and uranium mining, scandium is still valued for use in alloys with aluminium. Adding 0.5% scandium to aluminium greatly increases the metal's strength while maintaining its light weight, as well as raising its melting point by 800 °C so that, unlike ordinary aluminium, it can be welded. Russia has even stockpiled scandium for strategic reasons because several parts for advanced MiG jet fighters (pictured) are manufactured from this alloy. Meanwhile in the USA, scandium alloys are often used to make sports equipment such as baseball bats, lacrosse sticks and bicycle frames. It was also discovered that using such alloys to make cricket bats also improved their hitting power, but this was deemed 'unsporting' and scandium was immediately banned.

The primary form of refined scandium, the oxide, Sc_2O_3, also has a few specialized uses, even though world production amounts to only a few tonnes per year — and even less is converted to the metal itself. Scandium oxide provides a specialized optical coating for UV detectors[2], transparent to wavelengths between 0.25–5.0 µm, and is also used in neutron filters for nuclear reactors.

Other potential uses of scandium continue to be found. It is added to mercury vapour lamps to create a softer glow more akin to sunlight, and these lamps are often used in floodlights at sports venues. Scandium complexes show potential as hydroamination catalysts[3], and scandium sulfate does likewise as a seed germinating agent. Whether these applications of scandium become as prized as its use in fighter jets or as frowned upon as its use cricket bats remains to be seen. ❐

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Be B C N O F Ne Na Mg Al Si P S Cl Ar K Ca **Sc** Ti V Cr