

Tales of technetium

The story of the last element to be discovered out of the first 92 catalogued in the periodic table is told by **Eric Scerri**, who reminds us that technetium can be found a little closer to home than many of us might think.

Group 7 of the periodic table is something of an oddity. When the first periodic table was formulated by Mendeleev, it was the only group that contained just a single known element — manganese. In the early twentieth century, several claims were made for the discovery of the element immediately below manganese. But this alleged element, given various names such as davyum, illenium, lucium and nipponium, turned out to be spurious.

Then, in 1925, Otto Berg, Walter Noddack and Ida Tacke (later Ida Noddack), claimed to have discovered not just one but two new members of Group 7, which they named masurium and rhenium. Although their discovery of rhenium was soon accepted, their claim for the element directly below manganese has been bitterly disputed^{1–5} ever since. As recently as the turn of the millennium, Belgian physicist Pieter van Assche collaborated with several US spectroscopists to re-analyse the original X-ray images. They then argued that the Noddacks had in fact isolated another element in addition to rhenium. But this claim has also been disputed by a number of other researchers.

Traces of Tc in rocks contradict the common textbook statement that it does not occur naturally on Earth.

The official discovery of element-43 is accorded to Emilio Segrè and co-workers. Technetium, as they called it, was the last of elements 1–92 to be tracked down, and in fact it had to be synthesized rather than isolated from naturally occurring sources. It is also the only element to ever be ‘discovered’ in Italy — in Palermo, Sicily, to be more precise. Segrè, who had been a visitor at the Berkeley cyclotron facility

in California, was sent some molybdenum plates that had been irradiated for several months with a deuterium beam. Various chemical analyses by the Italian team revealed a new element, which could be extracted by boiling with sodium hydroxide that also contained a small amount of hydrogen peroxide.

It has generally been believed that any technetium that might have been present when the Earth was first formed has long since decayed radioactively. We know this because even the longest-lived isotope of the element has a half-life that is too short in comparison with the age of the Earth. But in 1956, the Japanese radiochemist Paul Kuroda predicted that a natural nuclear reactor might once have existed deep within the Earth. Five years later, he reported that a sample of African pitchblende contained about 2×10^{-10} grams of ⁹⁹Tc per kilogram of ore. In 1962, a team of French scientists confirmed Kuroda’s earlier prediction of a natural nuclear reactor on investigating rock samples in the Republic of Gabon in Africa. Further analyses showed that there were trace amounts of technetium present in these minerals too, thus further contradicting the common textbook statement that technetium does not occur naturally on Earth.

Turning to the skies, technetium was detected in some so-called red giant stars as long ago as 1952, but not in our own Sun, a fact that has had a significant role in confirming the view that the Sun is a relatively young star. In addition, because technetium isotopes have short half-lives compared with the age of red giants, this finding suggested that the element was being produced within the stars, thus supporting theories of stellar nucleosynthesis for elements of intermediate mass.

In spite of its exotic heritage, technetium is now widely used in

medicine as a diagnostic tool. Radioactive molybdenum-99 is allowed to decay to form technetium-99m — meaning ⁹⁹Tc in an excited nuclear state. This metastable isotope then drops to the ground state with the loss of a gamma particle, which can be recorded in radiodiagnostic procedures for the detection of tumours, among other things. The usefulness of ⁹⁹Tc lies in a number of specific properties that it has. The radioactive decay of the excited form has a half-life of six hours; that is long enough to be injected into a patient before

it decays, but still sufficiently short for its emission intensity to be measurable at low concentrations. Furthermore, the short half-life means that the patient need only be exposed to radiation for a brief period of time. The aqueous chemistry of technetium is also critical. The pertechnetate ion, TcO_4^- , which is the form in which the isotope is administered, is both soluble and stable over the physiological range of interest, unlike, for example, the permanganate ion (MnO_4^-).

Finally, one of the best ways to protect steel from corrosion when it is in contact with water, even at high temperatures and pressures, is to use a coating of KTcO_4 . It is unfortunate that technetium is radioactive, otherwise this method could be used in situations other than with steel in carefully sealed containers. □

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