Promethium puzzles

Stuart Cantrill explains why looking to the heavens for element 61 — named after the Titan who stole fire from the gods — could extend the periodic table.

Based on his studies of atomic weights, in 1902 Czech chemist Bohuslav Brauner predicted[1] the existence of element 61 — as well as six others that hadn't been discovered at that point. Just over a decade later, Henry Moseley's work with X-ray spectroscopy confirmed that there was a gap in the periodic table between neodymium and samarium, and so then it was just a matter of finding the missing element. But it wasn't easy.

Initial work centred on trying to extract the element from samples of rare-earth minerals. In the 1920s, claims of discovery — supported by X-ray emission data — were made on both sides of the Atlantic, in the USA[2] and Italy[3]. With competing claims came competing names: would element 61 be illinium (Il) or florentium (Fr)? The debate reached the pages of *Nature* on a few occasions, with William Noyes, former head of the chemistry department at the University of Illinois and past president of the American Chemical Society (ACS), getting involved[4].

But no one had actually isolated element 61, and so doubts began to grow. In the 1930s, theoretical work that suggested the element would not have any stable isotopes came as a further blow. Then, in 1937, following the identification of technetium in a piece of molybdenum foil that had been bombarded for months with a deuterium beam in a cyclotron at the Lawrence Berkeley National Laboratory, it became clear that gaps in the periodic table could be filled in a new way. If elements couldn't be found in nature, perhaps they could be made in the laboratory instead.

As the decade ended the world descended into war — one that would see the power of the atom harnessed. An important part of the Manhattan Project was to analyse the fission products of uranium to better understand the processes involved, and this led to a team of scientists at Oak Ridge in Tennessee finally isolating[5] element 61 by using ion-exchange chromatography. The official announcement was delayed until after the end of the war, and was made at the 1947 national fall meeting of the ACS in New York City.

Statue of Prometheus near the Chernobyl nuclear power plant. Credit: kpzfoto / Alamy Stock Photo

The name 'prometheum' was proposed for the new element by Grace Mary Coryell — the wife of one of the Oak Ridge team. Prometheus stole fire from the gods and gave it to humanity, but was punished by being tied to a rock where each day an eagle would feed on his liver (which would grow back at night). The name, which reflects the power and peril of nuclear energy, was accepted in 1949 by the International Union of Chemistry, but the spelling was amended to promethium to be consistent with other metallic elements.

All 38 known isotopes of promethium are radioactive; the longest-lived is Pm-145, with a half-life of 17.7 years. As a consequence of its instability, at any given time there is estimated to be only roughly 500 g of promethium on Earth (from the natural decay of europium and uranium)[6]. Compare this with its neighbours in the lanthanide series, neodymium to the left and samarium to the right, of which there are roughly eight and two million tonnes respectively.

Unsurprisingly, the chemistry of promethium is not very well developed, but simple salts such as halides and oxides have been prepared. Pm-147 has been used in luminous paints, in which its beta emission causes a phosphor to produce light; some electrical switches in the Apollo Lunar Modules were illuminated this way. Although safer than radium, the relatively short half-life of this promethium isotope (roughly 2.5 years) means that radioluminescent materials are now typically based on tritium. Promethium has also been used to make nuclear (or 'betavoltaic') batteries that served as power sources for some pacemakers in the 1970s.

Not too long after promethium was made on Earth it was detected in the spectra of stars that have highly unusual elemental compositions. Considering the short half-life (particularly on an astronomical timescale) of even the longest-lived promethium isotope, its presence in these stars is puzzling. Various theories have been put forward, including the idea that such stars could contain as-yet unidentified super-heavy elements from the 'island of stability' that would decay into promethium and other radioactive elements[7]. Alternatively, of course, it could just be a sign of alien technology[8]. ❐

Stuart Cantrill[1]
[1]*Chief Editor at Nature Chemistry.*
Twitter: @stuartcantrill
e-mail: s.cantrill@nature.com

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References
1. Brauner, B. *Nature* **118**, 84–85 (1926).
2. Harris, J. A., Yntema, L. F. & Hopkins, B. S. *J. Am. Chem. Soc.* **48**, 1594–1598 (1926).
3. Rolla, L. & Fernandes, L. *Z. Anorg. Chem* **157**, 371–381 (1926).
4. Noyes, W. A. *Nature* **120**, 14 (1927).
5. Marinsky, J. A., Glendenin, L. E. & Coryell, C. D. *J. Am. Chem. Soc.* **69**, 2781–2785 (1947).
6. Belli, P. et al. *Nucl. Phys. A* **780**, 15–29 (2007).
7. Dzuba, V. A., Flambaum, V. V. & Webb, J. K. *Phys. Rev. A* **95**, 062515 (2017).
8. Whitmire, D. P. & Wright, D. P. *Icarus* **42**, 149–156 (1980).