The germination of germanium

Shawn C. Burdette and **Brett F. Thornton** explore how germanium developed from a missing element in Mendeleev's periodic table to an enabler for the information age, while retaining a nomenclature oddity.

When German chemist Clemens Winkler analysed the mineral argyrodite that had been excavated from a mine near his hometown of Freiberg, he could not account for 7% of the total mass¹. The balance of the contents was identified as silver (75%), sulfur (18%) and some minor impurities. In 1886, after many failed attempts to isolate the elusive substance, Winkler finally precipitated a sulfide complex using a large excess of hydrochloric acid, and rigorously interrogated the material².

These investigations coincided with an era of confusion and clarification about the then-relatively-new periodic table. Mendeleev's seminal proposal for element organization had appeared in 1869, and an important part was the empty spaces he had left for elements yet to be discovered. Two of those predicted elements, gallium and scandium, were discovered in 1875 and 1879 respectively, and corroborative evidence was mounting. Nonetheless, some scientists still had doubts about Mendeleev's periodic table.

Recognizing that the missing component in argyrodite was a new element, Winkler dubbed it 'germanium' and proposed placing it between antimony and bismuth, based on chemical similarities with these known elements¹. One look at the modern periodic table makes this placement appear incongruous — but Mendeleev's table did indeed have such an opening for 'eka-antimony' between antimony and bismuth. After Mendeleev learned of Winkler's discovery, the two scientists, together with German chemist Julius Lothar Meyer, corresponded at length about the new element's anticipated and actual properties. Mendeleev doubted some of the initial hypotheses, even suggesting that the element might be eka-cadmium.

These seemingly bizarre suggestions arose because Mendeleev's tables wrapped the blanks for the then-unknown lanthanides into

the same groups as lighter main-block and transition elements. Only four elements were known between barium and tantalum, and the arrangement at the time made Winkler's suggestion of eka-antimony and Mendeleev's of eka-cadmium seem eminently reasonable. Obtaining the atomic weight of germanium, as Winkler noted in his first report¹, would resolve the positioning problem. Ultimately it was Meyer, with his assertion that germanium was in fact eka-silicium, who was proven right by analyses of the physical properties of germanium, which perfectly matched nearly all of Mendeleev's 1869 predictions for eka-silicium — including an atomic weight of 72.

In his extensive follow-up report on the identification and characterization of germanium², Winkler reported having received objections to his proposed name because it had too much of 'un goût de terroir' — that is, it was too nationalistic. He resisted any change, citing that both gallium and scandium paid homage to their discoverers' homelands. Although it was its root that was begrudgingly accepted, another aspect of the name could have invited scrutiny. Germanium, along with selenium, tellurium and helium, is one of the few non-metallic element to carry the '-ium' suffix in English³. This can seem an odd choice as the title of Winkler's original report, entitled 'Germanium, Ge, a new non-metallic element', plainly states he did not believe it was a metal¹; yet it is

consistent with the German name of the other group 14 metalloid, silicium.

With the invention of the point-contact transistor in 1947, germanium played a key role in solidifying the definition of metalloids as well as ushering in the information age⁴. The same characteristics that contributed to the challenge in isolating element 32 and placing it on the periodic table are also the attributes that impart it with semiconducting properties. For a time, the moderately uncommon element (~1.5 ppm in the Earth's crust) became a vital commodity, because it was easier to obtain in the necessary purity for the electronics industry than silicon until the 1960s. Although improvements in silicon refining temporarily reduced the industrial demand for germanium, recent years have seen a resurgence in its uses. Germanium now finds uses in optical fibres, polymerization catalysts, and Si-Ge alloys in microchip manufacturing, with feature sizes on the chips reaching 7 nm (< 60 Ge atoms).

Over 100 years after its discovery, the placement of germanium with the other metalloids along the dividing line between the metals and non-metals seems prosaic, even if its metallic nomenclature remains an aberration. □

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